ALCOHOL:

ITS ACTION ON THE HUMAN ORGANISM.

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SECOND EDITION (REVISED).

LONDON:
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IN November, 1916, the Central Control Board (Liquor Traffic) appointed an Advisory Committee "to consider the conditions affecting the physiological action of alcohol, and more particularly the effects on health and industrial efficiency produced by the consumption of beverages of various alcoholic strengths, with special reference to the recent Orders of the Central Control Board, and further to plan out and direct such investigations as may appear desirable with a view to obtaining more exact data on this and cognate questions."

The composition of this Committee in 1918, when they published the first edition of this book, is shown on page iv. Two further members were afterwards added : namely Dr. E. Mellanby, then Professor of Physiology in the University of London, and Dr. C. S. Myers, then Professor of Psychology in the University of Cambridge.

On the dissolution of the Central Control Board in 1921 the Medical Research Council were invited by the Secretary of State for Home Affairs to reappoint the Committee as one of their own investigation Committees, and so to preserve the continuity of the work. The Council, who had previously assisted in the research work undertaken for the original Committee, were glad to accept this proposal, and the Committee was accordingly reconstituted by the appointment of the non-official members, with the exception of Professor McDougall, who had left Oxford for his present chair at Harvard.

The present composition of the Committee is shown on page v.

The Committee as originally constituted prepared the first edition of this book, which was published in 1918. It was intended as a provisional basis for further research and as a review of the existing state of scientific knowledge as to the action of alcohol on the human organism, the conclusions formulated representing the unanimous judgment of the Committee.

In 1920, when they were still acting as a Scientific Advisory Committee to the Liquor Control Board, they made a careful revision of this first edition, especially with a view to incorporating the results of the investigations which they had promoted, along some of the lines of enquiry indicated in the preface to the first edition by the Chairman, Lord D'Abernon. To this revised edition Lord D'Abernon had contributed a second preface. Owing to circumstances over which the Committee had no control, this revised edition, as then prepared, was not published, and the issue of the original edition has continued down to the present day. The reconstituted Committee, however, have been able to use this earlier revision as the basis of the work which they have now undertaken to bring the book, so far as possible, into line with the latest results of research and experience. They thought it desirable to print, with this edition, the second preface which their former Chairman, Lord D'Abernon, wrote in 1920, and this will be found on page xv.

The postponement of the issue of the second edition for this further term of years has given the Committee the opportunity of considering some material which was not available for review, or criticism, at the earlier date. In particular, the recent issue of Professor Starling's book on "The Action of Alcohol on Man," to which one of their own members (Sir Frederick Mott) has contributed a chapter,

has brought to notice some new evidence, produced by Professor Pearl, on the effect of alcohol on longevity. This has been here considered in the appropriate chapter. In so far as Prof. Starling's treatise deals with the action of alcohol as determined by the methods of experimental physiology and psychology, or with its pathological effects, the Committee have been gratified to find that it shows no significant difference, in its record or interpretation of the available facts, from that which was put forward in the first edition of their own book. Professor Starling and his colleagues deal, in addition, with questions concerning the social value of alcohol, which, in the Committee's view, are at present, and are long likely to be, matters for individual judgment and opinion, rather than for scientific decision. They have, accordingly, adhered to their original conception, that such matters were outside the scope of a strictly scientific discussion of the evidence concerning the action of alcohol on the human organism. A new chapter on "Alcohol as a Medicine," which was prepared for the edition contemplated in 1920, has been included here.

Medical Research Council,
15, York Buildings,
Adelphi,
London, W.C.2.

12th December, 1923.

1918.

CENTRAL CONTROL BOARD (LIQUOR TRAFFIC).

ADVISORY SCIENTIFIC COMMITTEE UPON THE PHYSIOLOGICAL ACTION OF ALCOHOL.

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SIR GEORGE NEWMAN, K.C.B., M.D. (*Vice-Chairman*). Principal Medical Officer to the Board of Education. Member of the Central Control Board (Liquor Traffic).

Professor A. R. CUSHNY, M.D., F.R.S., Professor of Pharmacology at University College, London.

H. H. DALE, M.D., F.R.S., Head of the Department of Bio-Chemistry and Pharmacology under the Medical Research Committee, National Health Insurance.

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F. W. MOTT, M.D., F.R.S., Pathologist to the London County Asylums; Consulting Physician to Charing Cross Hospital.

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W. C. SULLIVAN, M.D., Medical Superintendent of the Rampton State Asylum for Criminal Lunatics.

1923.

MEDICAL RESEARCH COUNCIL.

ALCOHOL INVESTIGATION COMMITTEE.

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H. H. DALE, C.B.E., M.D., F.R.S., Director of the Department of Bio-Chemistry and Pharmacology in the National Institute for Medical Research.

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Professor E. MELLANBY, M.D., Professor of Pharmacology in the University of Sheffield.

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C. S. MYERS, C.B.E., M.D., Sc.D., F.R.S., Director of the National Institute of Industrial Psychology, London.

SIR CHARLES S. SHERRINGTON, G.B.E., M.D., F.R.S., Waynflete Professor of Physiology in the University of Oxford and President of the Royal Society.

W. C. SULLIVAN, M.D., Medical Superintendent of the Broadmoor Criminal Lunatic Asylum.

PREFACE TO THE FIRST EDITION.

By Lord D'Abernon.

The part played by alcohol in social industrial and economic life is so considerable that knowledge of its action on the human body might reasonably have been expected to be full and precise. The total amount of money devoted to the purchase of alcohol by the inhabitants of these islands is nearly 50 per cent. greater than the traffic receipts of the whole railway system, including both goods and passengers; it is more than double the expenditure on bread, and more than equal to the expenditure on meat: before the war it was approximately equal to the total revenue of the State, and was more than eight times the total amount required for interest on the National Debt. Apart from the economic aspect, it is admitted by all parties that the misuse of alcohol exercises a considerable influence on health and longevity, and it is contended by one large section of opinion that it is a main cause of crime and poverty. The ill effect on individual and national efficiency of excessive indulgence in alcohol is not disputed. In many other countries alcohol plays as great, and in some a greater part. It is remarkable, therefore, that, throughout the world, lack of exact knowledge still prevails about the action of alcohol on the human system. No authoritative scientific work gives or seeks to give the required information; on many important points, which it is requisite to elucidate in order to regulate the proper and legitimate use of alcoholic beverages, and also to furnish practical guidance to the individual consumer,

little of substantial value has been published in a form accessible to the general reader.

The absence of any authoritative work is perhaps partly accounted for by the fact that many of the essential data are not known even to science. A large amount of laborious experiment has, indeed, been directed to certain aspects of the action of alcohol; but the choice of questions for investigation has often been determined by the ease with which they could be put to the test, or by their bearing on some theoretical controversy, rather than by their intrinsic and practical importance. There are many points concerning the use of alcohol in daily life on which research has been so inadequate that knowledge with regard to them is both scanty and imperfect.

It may facilitate the understanding of what is meant by deficiencies, or lacunæ, in scientific knowledge regarding alcohol, if I state some of the points, many of considerable importance, as to which no data, or only very inadequate data, exist. I have adopted the interrogative form in order to give greater precision and clearness.*

(i) In what way, and to what extent, if at all, do solutions of ethyl alcohol in water, as commonly used in laboratory experiments, differ in their action on the nervous system from ordinary alcoholic beverages of corresponding strength, such as beer, wines, or spirits?

(ii) Are there any differences in inebriating action, and if so what differences, between the several sorts of alcoholic liquors when taken in doses of equivalent

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* Experiments directed to answering the first five questions in the above list have been carried out during the past year by Dr. Edward Mellanby.

Some very suggestive results have already been communicated to the Committee while this book has been passing through the press, but a final judgment as to their significance may be reserved until the full report of the research is ready for publication.

alcoholic strength ? Does the drunkenness caused by beer or wine differ in character from that caused by spirits ?

(iii) Is the effect on the nervous system of a given dose of alcohol modified when it is administered in a combination of alcoholic liquors ? Does mixing drinks tend to produce drunkenness ?

(iv) Does the greater or less degree of dilution in which it is administered modify the immediate action of a given dose of alcohol on the nervous system ? If so, why and how ?

(v) In what respect and through what mode of influence, if at all, is the action of alcohol affected by its administration with food ? To what extent does its action vary with the particular foods taken, *e.g.* fats and sugar ? Will a given dose of alcohol have a greater or lesser effect on nervous functions when taken with a meal than when taken on an empty stomach ? If there is any difference, is it due to a difference in the rate of absorption, or is it to be explained otherwise, and if so, how ?

(vi) Does the presence of fatigue modify the effect of alcohol on the performance of skilled movements ?

(vii) How does climate affect the amount of alcohol that can be taken without injury to health ? Is alcohol less injurious in moist climates than in dry climates ?

(viii) To what extent is the development of chronic alcoholism dependent on lesions of the stomach brought about by the directly injurious action of the alcoholic beverages on the mucous membrane ?

(ix) Does the feeling of increased cheerfulness induced by alcohol favour the resistance of the organism to adverse physical influences, such as cold ?

To none of these questions is it now possible to obtain a precise and authoritative answer. Yet it is of vital importance that knowledge regarding the points involved should be full and accurate. There are many further gaps in our knowledge. For instance, there is an almost

entire absence of reliable data regarding the psychology of the drunkard, though adequate information on this point is obviously essential to devising rational methods for the treatment of the inebriate. Little is known of the progress of the drinker from occasional excess to chronic alcoholism. Are the occasional drinker and the habitual drunkard two distinct types, or is the former an early stage of the latter ?

Further, there is a deplorable deficiency of reliable statistical data concerning alcoholic disease and mortality. This deficiency is due in part to the unsatisfactory system of certifying the causes of death, and also in some measure to absence of clinical investigation regarding the extent of the influence of alcoholism in bringing about the diseases associated with excessive drinking. This explanation does not, however, cover all the facts, for even in the case of diseases of unequivocally alcoholic origin, such, for instance, as delirium tremens, no general statistical records have hitherto been kept, save in isolated localities.

The usual explanation given to account for this position is that the subject is both difficult and ungrateful. It is held to be difficult because its investigation has to overcome obstacles even greater than those encountered in all experimental research which seeks to derive guidance as to the action of drugs in the human body from the behaviour of the same drugs in the test-tube, or from their effect on animals, and this for a simple reason. The action of alcohol on the higher centres of the brain—the action of special importance in relation to the ordinary use of the alcoholic liquors—can only be elucidated by investigation in man, and the results of such investigations, even when they can be objectively determined, are necessarily of very doubtful interpretation, owing to the complexity of the nervous functions in question, and the degree in which they may be affected by the idea on the part of the subject

that a given result is desired, or by bias felt by the subject as to the result of the experiment.

This special difficulty is enhanced by the fact that it is extremely hard to disguise the presence of alcohol when given in the doses necessary for experimental purposes, and that it is no less hard to counterfeit it satisfactorily in control doses.

Complication in arriving at the true effect of alcohol on performance further arises from the fact that while alcohol gives the drinker the impression that he has performed the allotted task with unusual facility and success, impartial and objective examination of the performance shows—almost invariably in cases where the higher faculties are concerned—that both accuracy and regularity have fallen below the normal standard. Self satisfaction has been increased, but neither skill nor power.

The extreme caution which these considerations impose upon students detracts from the brilliancy and certainty of any deduction from experiments, and tends therefore to render research less attractive than in other directions.

The second alleged reason is that alcohol is an ungrateful subject. The origin of this opinion may be traced to the general belief that most people who are interested in the subject are already partisans on the one side or the other, and that no body of impartial opinion exists which is ready to be guided by scientific inquiry. The majority of those who would give any attention to original work on the subject would do so, less to gain knowledge, than to find arms and arguments to support their preconceived opinion.

Whether or not these reasons are a true and complete explanation, there can be no doubt as to the fact itself, viz., that knowledge on the subject of the action of alcohol is inadequate to the needs and importance of the question. In view of this situation, the Central Control Board appointed a special Committee to consider the subject from a scientific point of view. Soon after its appointment, this Committee

came to the conclusion that it was essential, as a starting point for further research, to draw up a brief statement of the present position of knowledge. It appeared that by this means research would be most surely guided to those points which were of practical importance and regarding which knowledge was most urgent.

It also appeared certain that in view of the considerations mentioned above, no impartial statement of the case was likely to be made, unless it was drawn up by some public body. We felt it therefore incumbent upon us to enter upon the task, however invidious it might be.

In substance, this book is the outcome of the decision then arrived at. Its object is to separate what is knowledge from what is surmise, conjecture, or popular belief, and, by this preliminary clarifying of the question, to prepare the way for a further research. It may be claimed for the book that it is impartial, not only in the sense that the authors did not knowingly or of set purpose take sides with any existing body of opinion, but also in the further sense, that the writers have frankly admitted doubt, when the evidence appeared insufficient to establish a definite conclusion, and have further indicated with absolute sincerity the many points, some of them of great importance, regarding which no precise and scientific knowledge is available.

It will perhaps be urged that this attitude of mind mars the authority with which the conclusions are put forward, and that it would have been expedient to adopt a more didactic tone.

But I believe that complete sincerity is the only sure guide to the confidence of readers, and that the present condition of knowledge does not justify any more positive note. No subject has suffered more from over-statement, and from excessive violence both of opinion and of language, and on none, therefore, is caution in drawing conclusions more necessary.

In the final section of the Report will be found a brief summary of the principal conclusions to which the Committee have been led provisionally.

They are :—

(*a*) That the main action of alcohol (apart from the effects of its continued excessive use) is confined to the nervous system ;

(*b*) That alcohol is narcotic rather than stimulant in action ;

(*c*) That its nutritional value is strictly limited ;

(*d*) That its habitual use as an aid to work is physiologically unsound ; and

(*e*) That the ordinary use of alcohol should not only be moderate, but should also be limited to the consumption of beverages of adequate dilution, taken at sufficient intervals of time to prevent a persistent deleterious action on the tissues.

It is, of course, common knowledge that grave and widespread social evil follows in the train of excessive consumption of alcoholic beverages.

The physiological findings contained in the present Report have not been influenced by preoccupation regarding the social issues. But an increase of accurate knowledge as to the physiological action of alcohol cannot fail to be advantageous, both positively and negatively, to those whose duty it may be to deal with those issues.

Apart from affording a summary of whatever knowledge is available, it may be hoped that this work may to some extent stimulate the habit of scientific inquiry into the problems in which alcohol is concerned, and may make the temper in which they are discussed less passionate and more serene. I believe that nothing more beneficial could be imagined both as an aid to future State-action in regulating drink control and as a guide to the individual in

confining the use of alcohol within proper and legitimate limits.

Impartiality in investigation, caution in drawing conclusions, moderation in stating them, and a certain breadth in framing and applying regulations, will probably prove the best aids to effective and durable progress.

D'ABERNON.

December, 1917.

SECOND PREFACE.

(Written by Lord D'ABERNON in 1920.)

During the two years which have elapsed since the first edition of "Alcohol: its Action on the Human Organism," considerable progress has been made in the acquisition of data on which scientific knowledge may be based. The research work undertaken at the instance of the Committee by Dr. Mellanby, by Dr. McDougall and Miss Smith and by Dr. Vernon has thrown a large amount of valuable light upon previously obscure questions. In dealing with so difficult and complex a subject as the action of alcohol, it could not be expected that two years would suffice to clear up all the points at issue, but it may be confidently stated that not only has valuable theoretical knowledge been acquired, but the problems have been investigated in such a way that the data obtained should be of considerable practical use to the legislator and administrator.

Within the narrow limits of these prefatory remarks, it would be impossible to set out in detail the new facts established by the investigations to which I have referred: but a short and succinct statement of their main results may properly find place here, and may serve to bring home to the reader how much has been done to increase and to clarify our knowledge of the physiological action of alcohol, and thereby to furnish a firm basis of objective fact for the study and for the solution of the liquor problem. To put the gist of the matter into the briefest summary, it may, then, be claimed that recent research has yielded the following results:—

(1) It has proved the value and accuracy of physiological methods in estimating the action of alcohol on the nervous system, and in determining the effect of various conditions capable of influencing that action.

(2) It has shown that the rate at which a given dose of alcohol is absorbed into the blood stream can be largely modified—with an approximately equivalent modification of its inebriating effect—by the conditions under which alcoholic beverages are drunk.

(3) More particularly it has shown that alcohol in dilute solution is absorbed more slowly, and is therefore less inebriating than when taken in equal quantity in concentrated form. And it has demonstrated that a similar but more distinct weakening of its effect is produced when alcohol is taken with or soon after food, especially foods such as milk, containing fatty elements.

(4) It has also furnished some evidence—sufficient at all events to warrant further investigation—that there may be specific differences between the different sorts of alcoholic beverages in respect of the rate at which the contained alcohol is absorbed, and therefore in their inebriating tendency.

(5) It has given a definite measure to the rate at which alcohol is burned in the body, and has shown that the rate is slower than has been generally accepted, thus explaining the cumulative effect of drinking at short intervals.

(6) It has furnished important evidence in support of the view that alcohol does not, at any stage of its action, produce a stimulant effect on nervous functions.

On comparing this record of achievement with the enumeration of the chief lacunæ in our knowledge which I included in the preface to the first edition of this Report, it will be seen that definite replies have been furnished to most of the questions which were then propounded, and that some initial steps have been taken to deal with the remainder of the programme. As a result, however, of this very increase in our knowledge, fresh problems have been opened up, and the progress of events in the last few years has also brought into prominence aspects of the liquor problem which, nntil now, had seemed of secondary importance. In view of

these altered conditions, it is necessary to revise and in some respects to amplify, the lists of subjects to which research should be directed in the immediate future. Amongst the more important of these subjects I would indicate the following :—

(1) In what degree are the lighter beers and wines, as contrasted with distilled spirit, capable of inducing the bodily disorders of chronic alcoholism ?

(2) Is it possible, by further experimental enquiry, to ascertain more precisely the intervals that should be observed between drinking periods so as to obviate the risks of inebriation and chronic poisoning, assuming in each period a consumption of alcohol corresponding to average popular practice ?

(3) What, if any, is the influence of the regular moderate use of alcoholic beverages on the various forms of industrial efficiency ?

(4) Does parental alcoholism affect injuriously the health and development of offspring, and if so, are the resultant conditions transmissible to subsequent generations ?

(5) In what respects, if at all, do beers produced by different methods of brewing differ in their action on the nervous system and on the organism generally, and, in particular, are lager beers hygienically preferable to beers of equal alcoholic strength produced by top fermentation ?

(6) Is alcohol a habit-forming drug in the strict sense of the term, that is to say, does it create an organic need for continuance, shown by abstinence symptoms on its withdrawal ? Is the tendency observed in certain cases to its use in increasing and injurious doses a result of such habit-forming action, or is this tendency due solely to environmental conditions or to abnormalities in the constitution of the drinker ?

It will be readily observed that this new list of questions corresponds to a new orientation of the alcohol problem, which, in the light of the experience of recent years, has

become, from the practical point of view, and should remain a problem of moderate drinking rather than a problem of drunkenness. As was pointed out in the first edition of this Report and confirmed by experimental research and by the mass results of administrative action, it is now possible to ndicate the principle on which the use of alcoholic beverages can be regulated so as to minimise the risks of drunkenness and perhaps altogether remove those of chronic intoxication.

The translating of these principles into practice is a matter of legislation and administration, and, as such, lies outside the purview of the Committee.

1920. D'ABERNON.

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Alcohol:
Its Action on the Human Organism.

CHAPTER I.

Introductory.

The object before us is to answer the question, " What is known concerning the action of alcohol on the human body ? " An attempt is to be made to review and appraise all the evidence which is available concerning the action of alcohol, regarded simply as a subject of physiological and pathological investigation. It will appear that certain facts concerning this action can be accepted as established; that there are many others which, though less rigidly demonstrated, are supported by such evidence that they may be accepted as a basis of practical opinion; and that there are numerous directions in which information concerning the action of alcohol is still so vague and unsatisfactory, that no conclusion is legitimate, until further experiments have been made or more numerous and accurate data collected.

Definition of certain terms.

One of the first necessities of scientific discussion is to define, as precisely as possible, the meaning which is to be attached to any words concerning the significance of which there can be any doubt or possibility of misunderstanding. An endeavour will be made to define and explain, as they occur, the principal scientific terms which it may be necessary to employ in this book. The need

for accurate definition is especially felt, however, in the case of familiar words, which are in frequent and every day use. The meaning which popular usage attaches to such words is sometimes vague and illogical ; it fails to cover the whole of what the word means when used in a precise and scientific sense, and at the same time it suggests ideas which the word does not properly imply.

For example, a great deal of controversy has been devoted to the question whether alcohol is or is not a " food," and much of it has undoubtedly been due to the fact that the disputants were using the word " food " in different senses. In popular discussion the claim that alcohol is a " food " is frequently opposed by the production of evidence that it is a " poison," the two statements being regarded as mutually exclusive. When we come to enquire what precise meaning can be attached to each of these words, it will be clear that there is no reason why the properties indicated by both should not be present in the same substance ; so that the statements that " alcohol is a food," and that " alcohol is a poison," are not inconsistent, and may both be true.

We shall find, in fact, that both *are* true, if the words are used with the meanings which will here be defined. There is, further, an important part of the effects of alcohol, in many ways the most important, in producing which it cannot properly be said to act either as a food or a poison. We shall speak of these effects as the " drug " action of alcohol. We have, therefore, to consider three classes of effects produced by alcohol on the human body, three aspects of its action, which we call the action of alcohol " as a food," " as a drug," and " as a poison." Our first duty is to define as exactly as possible what is meant here by " alcohol," " food," " drug," and " poison."

What is meant by " Alcohol."

The chemist recognises a very large number of substances as " alcohols," applying the term to any substance having a

certain type of chemical constitution. Glycerin, for example, is an "alcohol" in this sense, as are many other substances to which the name would never be applied in ordinary usage. When the word alcohol is used by itself, without qualification, the substance referred to is what the chemist would call "ethylic alcohol." This is the ingredient of the various beverages known as "alcoholic drinks" or "alcoholic liquors" to which their inebriating properties are almost entirely due. The alcohol in these liquors is in all cases produced by the fermenting action of yeast upon sugar. The sugar may be that which naturally occurs in the juices of fruits, as when wines are obtained by the fermentation of the juice of grapes, or cider from that of apples. When barley is malted, a ferment (diastase) is produced, which, in the process of brewing, converts the starch of the grain into malt-sugar, and from this the alcohol of beer is produced by fermentation with yeast.

Constituents of fermented liquors.

By the fermentation of these natural sugary solutions liquors are obtained which contain only a relatively low percentage of alcohol. The fermentation, moreover, produces many other substances besides ethylic alcohol, though in much smaller proportions. Some of these are other alcohols; one in particular, called amylic alcohol by the chemists, is the principal constituent of the product known as "fusel oil." Others are members of other chemical series, such as "aldehydes" and "ethers." Some of these are present in the fresh fermented liquor, whilst others are formed during the process of maturation. When a wine is matured in wood, some of the constituents present in the raw new wine are slowly abstracted.

Distillation: substances found in distilled spirit.

Ethylic alcohol and the majority of these other substances boil at a lower temperature than water and are said

to be more "volatile." When, therefore, a fermented liquor is boiled down, the ethylic alcohol and other volatile substances evaporate more readily than the water; and when the vapour produced during the earlier part of the evaporation is condensed in a still, a fluid is obtained containing a much higher proportion of ethylic alcohol than the original liquor, with different but always very small proportions of the other volatile constituents. This was the old-fashioned method of obtaining the different "distilled spirits," which resembled one another in containing a high proportion of ethylic alcohol, and differed from one another in the nature and proportion of the other volatile constituents present, in addition to water. Thus, true brandy owes its characteristic flavour to traces of certain volatile constituents of wine; true whisky, prepared by the old-fashioned "pot-still," to those formed in the fermentation of malted grain; rum to those formed in the fermentation of molasses.

It will be seen, therefore, that wines, beers, and distilled spirits prepared as above described, all contain traces of other active substances besides alcohol. Some of them, such as the mixture of less volatile alcohols known as "fusel oil" (chiefly amylic alcohol), are much more poisonous than ethylic alcohol if given in equal doses. It has been thought that they may play a part in producing the bad effects which follow habitual excess in the use of alcoholic liquors. The suggestion is one which must be considered, but there is very little evidence to support it. The other volatile substances are present in such small traces that they cannot have much effect on any property of the spirit except its flavour. Some of them appear to be abstracted slowly when the spirit is "matured" in casks; the spirit acquires a more delicate flavour, and is less "fiery" to the taste. Tradition regards spirits so treated as more wholesome than the crude new product, and very probably they are so. At the same time we must not

lose sight of the fact that tradition and connoisseurship, in this as in other matters, are bound up with a good deal of convention and superstition. The modern scientific apparatus known as the " patent still " makes possible a much cleaner separation of the products of distillation. By its use a practically pure ethylic alcohol can be obtained, whatever the nature of the fermented liquor treated. Many of the cheaper brands of the different spirits consist of ethylic alcohol so obtained, diluted with water and appropriately flavoured to represent whisky, gin or rum, as the case may be. There is no reason to suppose that such preparations are weaker in inebriating action, or less permanently harmful if taken in habitual excess than the products of the old-fashioned still. They would probably be condemned by the educated palate of the connoisseur. Nevertheless, there can be no doubt that they present ethylic alcohol in a state of purity, which no amount of maturing and blending of " pot-still " whisky could achieve.

Ethylic alcohol the important constituent of the alcoholic liquors.

Without denying the possibility of a minor influence to other constituents, we can quite safely assume that ethylic alcohol is by far the most important constituent of alcoholic liquors, from the point of view of the actions which are here to be studied. This is the substance which is responsible for practically the whole of that action on the body, which distinguishes these drinks from those called non-alcoholic, and which is the main reason for their use.

We may, therefore, without any serious inaccuracy use the simple word " alcohol " when we are speaking of the action of ethylic alcohol, whether it is taken as the chemically pure substance diluted with water, as in many of the experiments which we shall have to describe, or in the more complex fluids, such as beer, wine or brandy, in which it is

used in everyday life. This is the sense in which the word "alcohol" will be used throughout this book.

Definition of "Food."

In defining the meaning of the word "food," it will be useless to try to frame a definition which shall include everything which everybody admits to be a food, and exclude everything which is not so recognised by all. For there are some who maintain that alcohol is not a food, and if we frame our definition so as to exclude it, we decide in advance the question we have to discuss; it becomes a mere matter of words and definitions and has no real meaning. If the question, whether alcohol is a food, is to have any real significance, we must ask ourselves, what are the properties implied when the word "food" is used in its ordinary sense. We must define those properties in a precise and scientific manner. The question can then be answered by a consideration of the scientific evidence, as to whether alcohol has or has not the properties so defined.

A food, in the first place, is something which we eat or drink, which is useful for the normal life of the body and of its constituent parts. But such a definition would include substances like water and various salts, which are indispensable constituents of the body, but are not usually regarded as foods. If the "man in the street" is asked why he does not regard water and salts as foods, he will probably reply that they do not appease his hunger.

If this reply is put to the physiologist, he will agree, and will proceed to explain why. He will explain that water and salts are not used or altered by the body. The body is constantly losing water by evaporation from the lungs and the skin, and both water and salts in the urine and the sweat. To replace these, and preserve the normal amount of water and salts in the body, we need frequent fresh supplies; but they pass through the body without change.

Consider now the case of a substance such as sugar,

which everybody recognises as a food. If sugar be eaten in any ordinary quantity it disappears completely as sugar, and no more of it can be recovered than if it is thrown into the fire and burned. And, indeed, the changes undergone by sugar when it disappears in the body are, in the end results, identical with those which occur when it is burned in the fire. In both cases it combines with the *oxygen* of the air, with evolution of heat, and the substances resulting are carbonic acid gas and water. The body gets rid of these in the breath and the urine.

Oxygen and oxidation : carbonic acid.

Oxygen is a gas which forms about one-fifth of the air. When a substance burns in air it enters into combination with the oxygen. Oxygen is likewise the constituent of the air, which, when breathed, supports life ; life is, indeed, essentially a slow combustion. Sugar contains the elements carbon, hydrogen and oxygen. When additional oxygen is supplied, and the temperature is raised sufficiently high, combustion takes place, the carbon of the sugar combining with oxygen to form carbon dioxide, and the hydrogen with oxygen to form water. Carbon dioxide is the gas often called carbonic acid, which causes the effervescence of beer, etc., and " aerated waters " are artificially impregnated with it. The process of combining with oxygen is often spoken of as " oxidation."

How the body obtains energy from food.

There is another analogy between the burning of a combustible substance, such as sugar, in air, and the oxidation or combustion which it undergoes in the body. All are familiar with the fact that the heat which is generated by burning such a substance can be made to do work, by the use of an appropriate engine ; in the language of Mechanics, part of the " energy," which is liberated when a

substance is burned, can be obtained in the form of mechanical work, though with even the most perfect engine a large part is dissipated in the form of heat. The body, just as truly as a steam-engine, obtains the energy for carrying out the work performed by its different organs by the combustion or oxidation of different materials ; like the engine, too, the body obtains the liberated energy partly in the form of mechanical work—the work performed by the muscles in moving the body or lifting weights, and by the heart in driving the blood in circulation—but partly as heat, which maintains the normal warmth of the body. Now all the substances which we recognise as *foods* can thus undergo combustion in the body, and supply the heat and the power of doing work which distinguish the living from the dead body. Water and salts on the other hand, while essential to life, only supply the conditions necessary for the use of other substances by the body ; but they are not themselves consumed in the process, cannot themselves furnish the energy which the body requires, and therein differ from the foods.

Accessory substances.

The same may be said of the so-called " accessory substances," or " vitamins," the importance of which has been made clear during recent years. These are substances of which the nature is still obscure, which must be present in minute quantities in the diet if normal growth and the healthy life of the body are to be maintained, but are not themselves a source of the energy which the body needs.

Food as fuel : the several classes of foods.

We have advanced a step further, therefore, in our definition of a food. *A food is not merely something which is useful for the normal life of the body ; it is a fuel which the body can use as a source of energy.*

Leaving the case of alcohol out of account for the

present, we find that all the important constituents of our diet, which are capable of acting thus as true foods or fuels to the body, fall into three classes :—

1. The carbohydrates, including starches, gums, and sugars.
2. The fats.
3. The proteins, or albuminous substances.

If we make a chemical examination of the body, we find that it contains substances belonging to all these three classes, though not necessarily in any case the same individual substances as the food contains. By the processes which we call " digestion " the body breaks down all the food-materials, when necessary, into simpler, soluble substances. These are readily absorbed, and from them the body builds up again its own carbohydrates, fats and proteins.

Special position of the proteins.

The proteins are in a special position. They form an essential constituent of every part of the body which is living. The element *nitrogen* enters into their composition, but not into that of fats or carbohydrates. The body, therefore, cannot form protein from fats or carbohydrates ; to repair the waste of its tissues it must have protein in the food. So that a certain quantity of protein is, in a peculiar sense, an indispensable constituent of a diet.

Carbohydrates and fats are not indispensable in the same sense. If the food contains more protein than is required for the repair of tissue, the body can form carbohydrate or fat from the remainder. But when carbohydrates and fats are given as well, as in an ordinary diet, the body requires very much less protein than if it had to be maintained on protein alone. Excess of carbohydrate can be stored in the body as a special carbohydrate

called " glycogen," a sort of animal starch ; or it can be converted into fat and stored in that form. Excess of fat in the diet can similarly be stored as body-fat. The well-nourished body, therefore, always contains a good reserve of these food-substances or fuels. If no food is taken for a prolonged period, but only water, the body draws on its own reserves of fuel to maintain the supply of energy. It uses first the fat and carbohydrate, which are stored for this purpose, and when these are exhausted consumes the proteins of the less important tissues, such as the muscles of the limbs and trunk, to maintain the supply of energy for those which are more essential for the continuance of life.

Ordinary food-stuffs can be used for tissue repair, or stored in the body.

We have, then, another property of all these three classes of food-substances. They can not only serve as fuel for the body's immediate requirements of energy, but can furnish material for the repair of the natural waste of the living tissues, or for replenishment of the fuel-reserve which the body normally maintains. The body not only can use them, but can store them for future need.

Are we to regard this also as an essential character of a " food," and refuse to apply that term to substances which can be used as immediate fuel, but cannot be changed by the body into glycogen or fat for storage ? The question is a very important one for our present purpose, because on the answer to it depends our conclusion as to whether alcohol is a " food " or not. On the whole it has appeared to us more logical to admit that such immediate fuel-substances are " foods " also ; for although they cannot themselves be stored, or changed into something which can, by meeting the immediate demand of the body for fuel they prevent the deple-

tion of the reserve. Their addition to a diet will, in the same way, allow the body to use for replenishment of its fuel-reserve carbohydrates and fats which it would otherwise have to use immediately. So that such substances have, in fact, the same effect in a diet as an additional supply of carbohydrates and fats; they have, to a limited extent, the same effect as substances which are undoubtedly foods, though they do not produce it in exactly the same way.

Physiological classification of food-substances.

We shall, therefore, adhere to our simple definition, that *a food is a fuel which the body can use as a source of energy.* But we must further recognise that the question is not a simple one: that there are degrees in the scale of importance applicable to food substances, of which we can distinguish three.

Class 1. Substances which can serve as fuel, to supply the energy required for the life of the body, and which can also supply the material required for the repair of the living structure. Theoretically the body could supply all its needs from such substances, together with water, salts, and the requisite traces of the "accessory substances" mentioned above (page 8).

To this first class belong the proteins alone.

Class 2. Substances which can serve as fuel directly, and can also be used to replenish the fuel-reserve of the body.

To this class belong the carbohydrates and fats.

Class 3. Substances which can serve as fuel, but are only available for immediate use. They cannot be used to form new materials for the body's fuel-reserve; but they can help to maintain that reserve by reducing the need for drafts upon it, and by allowing substances of Class 2 to be used for its replenishment.

Instead of asking the bare question, "Is alcohol a

food" ? we shall obtain information of much greater importance and interest by asking, "Does alcohol belong to any of the above classes of food-stuffs, and if so, to which" ?

Alcohol a fuel food which is only available for immediate use.

We shall find that the evidence leads to the conclusion that alcohol is a food of Class 3 ; indeed, it is the only important constituent of an ordinary dietary belonging to that class. We must make the position quite clear. If anyone chooses to maintain that the word "food" should be restricted to substances included above in Classes 1 and 2, he is perfectly entitled to do so. He would then be justified in stating that alcohol is *not* a food, provided that he made perfectly clear the limited sense in which he was using the word. We have chosen, for reasons stated, to allow the word a more extended application. We shall review the evidence which shows that alcohol is a food in this wider sense, and indicates the class of food-stuffs to which it belongs, and the limits imposed on its value as a food by its other properties. No one has the right to quote us as making the statement that alcohol is a food, unless he defines, as we do, the exact sense in which the word is used, and the limits within which the statement is true.

Definition of metabolism.

In discussing the food-value of alcohol we shall frequently have occasion to use the term "Metabolism," and it will be convenient to define its meaning now. The word metabolism is used by the physiologist to denote the sum-total of the chemical changes that take place in the body. The engineer who

wishes to measure the efficiency of his engine keeps careful record of the fuel consumed, the mechanical work done, and the amount of energy lost as heat. Similarly the physiologist conducts on the living man or animal what is called a " metabolism experiment," though the measurements and analyses required are far more numerous and elaborate than those which are needed for the relatively simple mechanism of the steam-engine or the petrol-motor. A man, or some other animal, is placed in an observation chamber. Everything that he eats or drinks and the air that he breathes are measured and analysed. All the products of metabolism, coming out in the breath, through the kidneys or by the bowels, are measured and analysed with the same care. The amounts of work performed and of heat lost are recorded, as well as the weight of the subject at the beginning and end of the observation. From all these data information is obtained as to the mode of working of the body, regarded as a machine, and a study can be made of the effect of adding a particular substance, such as alcohol, to the food. We shall see that by such means evidence has been obtained which enables us to reply to the above questions whether alcohol is a food, and to which class of food-substances it belongs.

Definition of drug action.

Apart from serving as food-materials, in the manner already indicated, substances can influence metabolism in other ways. There are substances which, when they are taken into the body, can accelerate, retard, or otherwise modify the delicate action of various parts of its mechanism, independently of any contribution to the supply of energy. Such action we propose in this statement to term " drug-action," and to refer to such substances as " drugs."

What is meant by the term " drug."

The word " drug " is used in different senses by different classes of people. In popular phraseology it often means a substance of a deleterious nature. As we use it here, it should not be taken to imply a necessarily harmful action ; we use it simply to mean a substance which temporarily modifies the activity of the bodily organs, including, of course, the brain and nervous system, otherwise than by increasing the supply of available energy. As an example of a pure drug-action, in this sense, we may take that of nitrous oxide—the anæsthetic gas used by dentists. When this gas is breathed the patient rapidly loses consciousness, while the rate of his breathing and of his heart-beat, and the activity of his muscles, are conspicuously modified. When administration of the gas is stopped, he rapidly rids himself through his breath of all the nitrous oxide which he had absorbed, and his brain and organs return to their normal state of activity. The nitrous oxide has profoundly modified the bodily functions without being used up or in any way entering into the chemical changes which we call metabolism. The effect of another familiar anæsthetic, ether, differs from this, not only in the fact that it is more prolonged, but because a small proportion of the ether taken into the body is burned ; so that ether to a very small extent enters into metabolism, and to that extent its action is that of a *food*, in the sense mentioned above. Nobody would think of describing ether as a food, or of suggesting it as a constituent of a diet ; its food-value is trivial, and its drug-action predominant. When we come to consider alcohol, the case is different ; but the difference is only one of degree. Alcohol is a common article of diet, and its food-value has been the subject of much controversy. But independently of any conclusion we may reach on that point, as the result of our examination of the evidence, we have to recognise that, like ether, it possesses drug-action. We shall give reason, indeed, for deeming this the most im-

portant of the actions of alcohol, as taken by the majority of those who use it.

Importance of drug action of alcohol.

For, though alcohol does, in the sense already indicated, act as a food, it is seldom taken primarily for that reason. It is to its drug properties and to the agreeable taste of the fermented liquors that we must look for the origin of the habit of using the drinks containing alcohol and of their position in popular esteem. A large section of our statement will be concerned, therefore, with the details of the action of alcohol as a drug. We shall discuss to what extent this action is useful to the healthy and to the sick, and to what extent it is harmful. It will be clear also that a final estimate of the value of alcohol as a food must involve consideration of the extent to which its use is limited by the nature of its drug-action.

Definition of poison action.

Practically every drug when used in excessive quantities, or under exceptional conditions, becomes a poison ; that is to say, it so greatly interferes with the normal working of the bodily functions that it endangers life. When life is endangered or terminated by a single large dose of a drug, we speak of the effect as " acute poisoning," and we shall have to discuss the phenomena of acute poisoning which a single large dose of alcohol will produce. On the other hand there are many drugs which, when taken habitually for long periods, produce structural and other changes of important organs, which ultimately lead to permanent ill-health, and may be the cause of death. We call such a condition " chronic poisoning." It should be noted that the chronic effects may have no relation whatever to the symptoms of what we have called the " drug-action," or of acute poisoning by the same substances. Each individual dose, from the

succession of which the chronic poisoning results, may be so small as to produce but slight symptoms of drug action, and those of an agreeable and apparently favourable nature.

Short of dangerous illness or death, there are minor defects and infirmities, affecting perhaps only some organ or system which is not essential to the life of the individual, which may result from chronic poisoning. The body may, through the prolonged action of a poison, acquire a weakness, a lessened resistance to disease or injury, which is imperceptible in health, and only becomes manifest when the subject is exposed to infection or violence. We shall have to discuss the possibility of the body being affected in any of these ways by the habitual use of alcohol.

CHAPTER II.

Alcohol as a Food.

Absorption of alcohol.

In considering the value of any substance as a food, it is necessary to know in the first place, to what extent, and with what rapidity, it is absorbed from the stomach and intestine ; for it is not until the substance has passed into the blood, by the circulation of which it is distributed to the tissues which can make use of it, that the true action as a food begins.

However easily combustible a substance may be outside the body, unless it is soluble in the blood, or can be changed by digestion into something which is soluble, it cannot act as a food. A substance like paraffin, for example, although it burns readily in air, is completely insoluble in the fluids of the body, and when it is taken into the stomach, it passes unchanged through the intestine and does not act as a food at all. Alcohol, on the other hand, is completely soluble in water, with which it mixes perfectly in all proportions, so that it does not need to be rendered soluble by digestion. We should expect it, therefore, to be absorbed quickly and completely ; experiment has shown that this is the case.

Analyses of the contents of the stomach and intestines, made at different intervals after a dose of alcohol has been swallowed, show that about one-fifth of it is absorbed from the stomach. In the uppermost section of the small intestine one-tenth is absorbed, but the main absorption, accounting for one-half of the quantity taken, occurs in the middle part of the small intestine, the remaining one-fifth being absorbed in the third and last section. By the time the alimentary contents reach the large intestine, all the alcohol has been taken up from them into the blood.

The absorption of alcohol is, therefore, complete, and, in comparison with that of foodstuffs needing preliminary

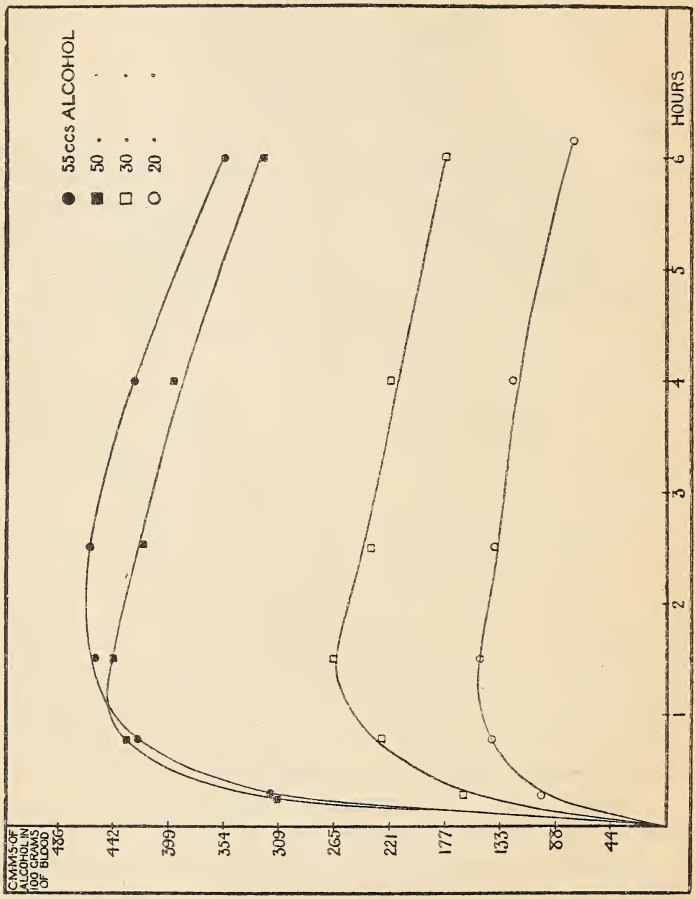
55ccs ALCOHOL
50 "
30 "
20 "
CMMS OF ALCOHOL IN 100 CMMS OF BLOOD
HOURS
442
399
354
309
265
221
177
133
88
44
1
2
3
4
5
6

FIGURE 1.

digestion, such as meat, it is conspicuously rapid. Thus, when a dose of alcohol is given to a man or other animal on an empty stomach, its presence can be detected in the blood within a few minutes ; and if samples of the blood are taken at intervals after the dose is swallowed, and the proportion of alcohol in each sample is determined by analysis, it is found that the concentration of alcohol in the blood rises rapidly to a maximum, which, when other conditions are constant, bears a regular relation to the original dose. The experiments on this point, carried out for the Committee by Dr. E. Mellanby,* show that the level of maximum concentration, marking the completion of absorption, is reached in from ½ to 2 hours (Fig. 1).

Conditions affecting the rate of Absorption.

The actual speed of absorption seems to vary with a number of conditions, such as the form in which the alcohol is taken, the extent to which it is diluted, and the time in relation to meals. The influence of these several conditions has been investigated by Dr. Mellanby in experiments on the dog and on man. With regard to dilution, he has found that when a given dose of alcohol is administered at 20% strength, the alcohol is more rapidly absorbed and reaches a higher level in the blood than when the same quantity is taken in 5% solution (Fig. 2). This effect of dilution in delaying absorption is most evident when relatively large doses of alcohol are drunk.

Confirmation of Mellanby's results has been provided by Miles,† who found in the human subject that the concentration of alcohol reached a higher level in the blood when given in a more concentrated than in a weaker solution. Thus when 27·5 grammes of alcohol were given in 100 c.c. of liquid the concentration in the blood at its highest point, 70 minutes after ingestion, was 43 milligrammes per 100

* Medical Research Committee, Special Report No. 31, 1919.

† J. Pharmacol and Exper. Therap. Vol. XX., p. 265, 1922–3.

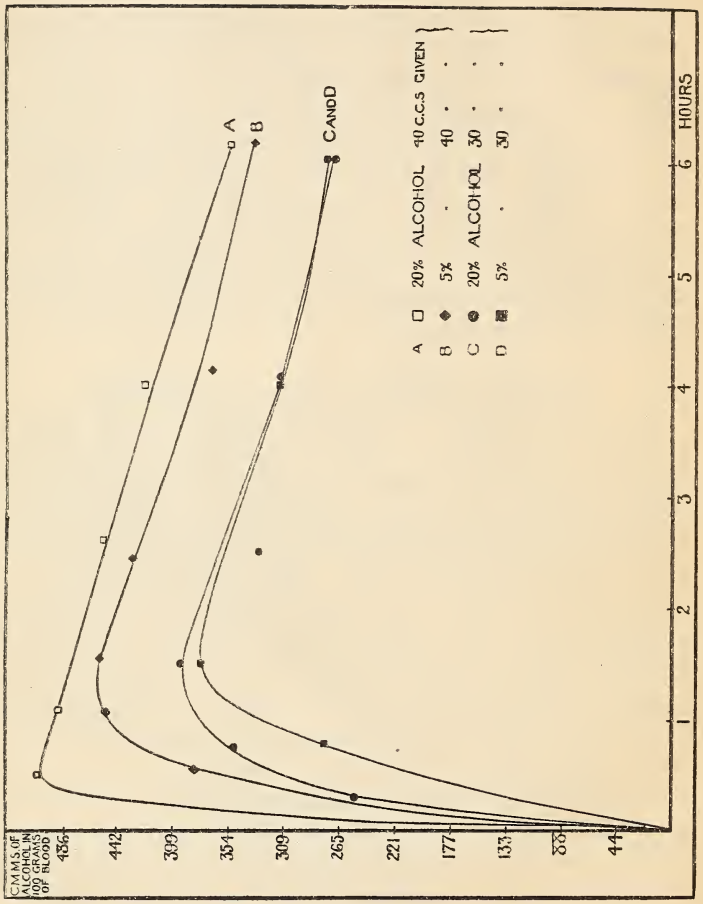
CM.M.S OF ALCOHOL IN 100 GRAMS OF BLOOD
436
442
398
354
309
265
221
177
133
88
44
1
2
3
4
5
6
HOURS
A
B
C AND D
A 20% ALCOHOL 10 C.C.S GIVEN
B 5% " 40 " "
C 20% ALCOHOL 30 " "
D 5% " 30 " "

FIGURE 2.

c.c. ; and when given in 1,000 c.c. of liquid, the concentration only reached 30 milligrammes per 100 c.c.

When alcohol is taken with or soon after food, the presence of the latter in the stomach constitutes, of course, a sort of dilution ; but Dr. Mellanby's researches show that the consequent effect on the rate of absorption is, at all events in the case of certain kinds of food, very much greater than can be accounted for by the influence of this diluting action alone. Thus it was found that alcohol, swallowed within $2\frac{1}{2}$ hours of a meal of milk or of bread and milk, was absorbed more slowly and reached a lower level in the blood than was observed under any other experimental conditions (Fig. 3). Further tests showed that the fatty elements in the milk were the important agent in delaying absorption, relatively little effect in this direction being produced when separated milk was substituted for whole milk. Meat, again, was found to have only a very slight influence in retarding absorption. Mellanby also made some investigations regarding the rate of absorption of alcohol from different sorts of alcoholic liquors, and found that it was decidedly slower when alcohol was drunk in the form of stout than when it was taken, in equal dose and equal bulk of fluid, as dilute spirits.

In confirmation of Dr. Mellanby's results it has been found by Dr. Vernon, who measured the effect of alcohol on speed and accuracy in typewriting, and by Dr. McDougall and Miss May Smith, using a variety of psychological tests, that the disturbing influence of the drug on neuro-muscular co-ordination, on attention, on the capacity for memorising and on other forms of mental activity, was greatly diminished when alcohol was taken with or soon after food ; and that its effects were also retarded and decreased by dilution.

Excretion.

The second point on which information is required, in estimating the food-value of a substance, is the extent

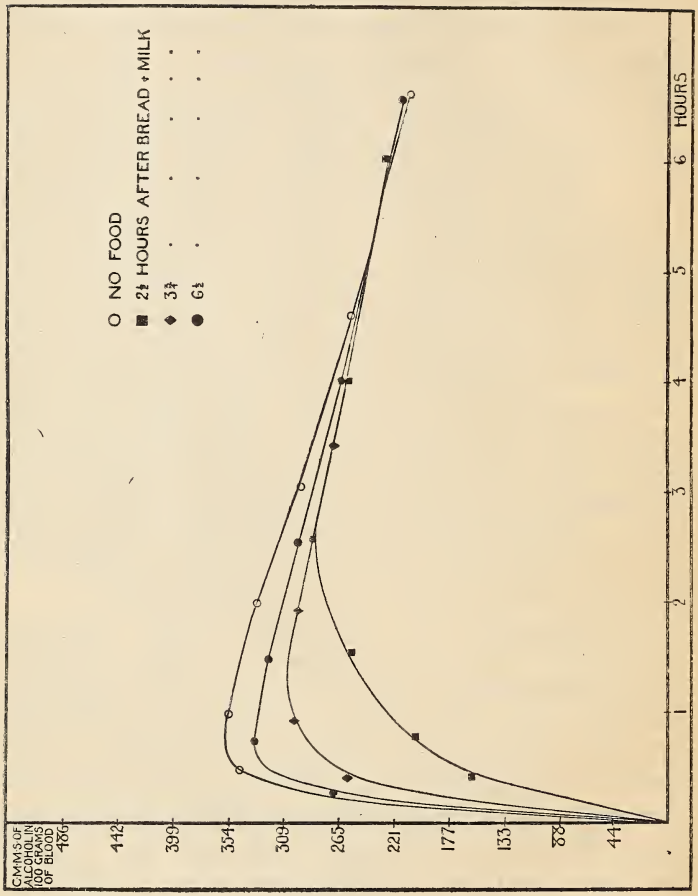
CMMS OF ALCOHOLIN 100 GRAMS OF BLOOD
486
442
398
354
309
265
221
177
133
88
44
O NO FOOD
2½ HOURS AFTER BREAD + MILK
3½ . . . . .
6½ . . . . .
1
2
3
4
5
6 HOURS

FIGURE 3.

to which the body can use it after it has passed into the circulation. We can obtain an indication of this by determining to what extent it leaves the body again unchanged. The processes by which the body discharges materials which it does not use further are collectively termed " excretion " by physiologists.

Mention has been made of the case of sugar, any ordinary quantity of which is burned completely in the body, so that, except in some diseased conditions such as diabetes, no sugar can be found amongst the waste materials in the urine. Sugar, therefore, is used by the body to its full value. We may contrast with this the case of saccharin, a complex coal-tar derivative, which is sometimes used in place of sugar, on account of its intensely sweet taste. Saccharin, in ordinary quantities, is absorbed completely from the stomach and bowel, but the whole amount taken can be recovered unchanged in the urine ; so that saccharin is not a food at all, and its whole value is in its sweetness.

Alcohol, being a substance which readily evaporates, can leave the body to some extent in the breath,* as well as in the urine, and both must be analysed in order to determine the proportion of a dose of alcohol which is excreted.†

* It should be noted that the odour of the breath, associated with the taking of alcoholic liquors, is mostly due to other substances than alcohol, which has but a faint odour.

† There is no evidence that alcohol is ever eliminated in appreciable amount in the sweat. Traces of the drug have been found in the milk, in experiments in which large doses of alcohol were given to cows and goats ; and some observers have also detected its presence in the milk of women of alcoholic habits. It is probable, however, that this occurs only when large quantities of alcohol are taken, and that, even then, the amount excreted is too small to have any influence on the health of the infant. In this connection it may further be mentioned that the available evidence gives no support to the popular belief that alcoholic beverages, and particularly malted liquors, promote the production of milk, and are therefore to be recommended to nursing mothers. Whether in the form of spirits or of beer, alcohol does not seem to have any effect whatever on either the quantity or the quality of this secretion. (R. Rosemann, in Pflüger's Archiv, Vol. 78, 1889).

In all the experiments of this kind which have been made this proportion has been found to be a small one, though it is not constant. It is increased by any influence which quickens the absorption of alcohol from the stomach and intestine, or the formation of urine by the kidneys, or which augments the vigour of the respiration. But under the conditions most favourable to this loss of unchanged alcohol in the breath and urine, it never amounts to more than one-tenth of the quantity swallowed. Usually much less is lost in this manner—on an average about one-fiftieth ; and in people who, by taking alcohol habitually, have acquired the power of using it up more rapidly than those unaccustomed to it, as little as one-hundredth part of a moderate dose of alcohol may escape in the breath and the urine.

The quantity of alcohol excreted as such by the body is always small, therefore, and may be trivial. What becomes of the remainder ? This question must be answered before any conclusion can be drawn as to the food-value of alcohol.

How the body uses alcohol.

It was pointed out above that alcohol taken by the mouth is rapidly absorbed into the circulation, and reaches a maximum concentration in the blood in from $\frac{1}{2}$ to 2 hours. From this point, as illustrated in Figures 1-3, the amount of the drug in the blood falls slowly and regularly until, after a time, which varies with the quantity drunk, it disappears altogether. The rate at which it disappears in dogs has been estimated by Mellanby at 0.185 c.c. per kilogramme of body weight per hour. A man of 10 stone weight disposes of about 7·10 c.c. of absolute alcohol in an hour, or about two-thirds of a pint of proof spirit in 24 hours.

This destruction of alcohol begins as soon as it enters the blood ; but, as the process is relatively slow, only a

trivial amount of the drug is eliminated in the period before absorption is completed : and so it comes about that, except when the quantity drunk is quite small, the maximum concentration of alcohol in the blood bears a fairly regular relation to the original dose.

Thus, it was shown by Gréhant* that when an animal had taken a dose of alcohol equivalent to one-thousandth of its body weight (*i.e.*, a dose of 1 cubic centimetre per kilogramme), the highest proportion subsequently found in the blood was about 1 per thousand ; with a dose of 2 c.c. per kilogramme the blood contained about 2 per thousand, and so on.

Products of combustion of alcohol.

What has become of the alcohol ? Only a little of it can be found passing out of the body ; and yet, after a time, none can be found in the body. There being no evidence of its change into some other substance which the body can retain, the supposition is natural that it is completely "oxidised" or burnt, producing, as when burnt in air, carbon dioxide and water, which pass out in the breath and urine. The method by which this supposition can be put to the test of direct experiment must now be described.

All food-substances contain carbon and hydrogen, and therefore yield carbon dioxide and water when they are oxidised in the body. The carbon dioxide leaves the body very quickly in the breath, the rate and depth of breathing being normally so adjusted as to keep the amount of it in the blood nearly constant (see p. 73).

The quantity of carbon dioxide and water formed, and, therefore, the amount of carbon dioxide passing out in the breath, varies from minute to minute, with changes in the activity of the muscles and other organs. A mere measurement of the rate at which carbon dioxide is turned out in

* Gréhant.—Comptes rendus de la Société de Biologie, 1881, 1896, and 1899.

the breath, after alcohol has been taken, will not give much information as to the extent to which alcohol is oxidised. For, even if variations due to the activity of the muscles or other organs were excluded, an increase in the production of carbon dioxide, following a dose of alcohol, would not necessarily mean that the alcohol was being burnt. It might mean merely that the taking of alcohol caused the body to burn more fat, carbohydrate or protein. Another measurement is needed as well, namely, the rate at which oxygen is used up in the air which is breathed.

The Respiratory Quotient.

When a carbohydrate, such as sugar, is burnt in the air, the volume of oxygen which disappears from the air is exactly the same as the volume of carbon dioxide which is formed. This is not true of any other food-substances; when fats or proteins are burnt, the volume of oxygen used is always larger than that of the carbon dioxide which is produced. And there is a difference of the same kind, but greater, when alcohol is burnt.

Readers with a slight knowledge of chemistry will readily understand the reason of this difference. Carbohydrates, fats and alcohol are all composed of carbon, hydrogen and oxygen. The amount of oxygen present in a carbohydrate is just sufficient to combine with all the hydrogen to form water, so that when a carbohydrate is burnt only sufficient extra oxygen is required to combine with the carbon; and when oxygen combines with carbon, the volume of carbon dioxide formed is equal to that of the oxygen used. Substances like fat contain a smaller proportion of oxygen, insufficient to combine with all their hydrogen, so that, when they are burnt, they use up a volume of oxygen which is larger than that of the carbon dioxide which is formed. The difference is still larger in the case of alcohol, which contains a smaller proportion of oxygen than the fats.

The same difference between carbohydrates and other food-substances appears when they are used in the body. By analysing the air which is breathed in and that which is breathed out by a man, or other animal, over a long period, the amount of oxygen used and the amount of carbon dioxide formed in the body are determined. These are compared by making a fraction :—

$$\frac{\text{Volume of carbon dioxide formed}}{\text{Volume of oxygen used,}}$$

and this is called the "*respiratory quotient.*" When the two volumes are nearly equal, so that the value of the fraction approaches unity, we know that the body is using chiefly carbohydrates. When the volume of the oxygen used is greater in proportion so that the respiratory quotient becomes smaller, we know that some food-substance other than carbohydrate is being burnt. The respiratory quotient resulting from the oxidation of alcohol would be lower than that corresponding to any of the ordinary food-stuffs ; so that, if alcohol is oxidised in the body, the addition of alcohol to the diet should be followed by a fall of the respiratory quotient.

Degree to which alcohol is oxidised in body.

A series of elaborate and careful experiments of this kind was carried out by Atwater and Benedict* in America, and their observations have been confirmed by other workers. The results give definite proof that alcohol is oxidised in the body as completely as the carbohydrates, and rather more completely than the fats and proteins.

Alcohol a fuel food.

It has been suggested that the energy liberated by this oxidation of alcohol cannot be used by the body, but is lost in the form of superfluous heat. This possibility has

* Physiological Aspects of the Liquor Problem, New York, 1903

been examined and disproved. Atwater and Benedict were able to show that the body can derive up to one-fifth of the total energy it requires from the metabolism of alcohol. There can be no doubt, therefore, that alcohol is a " food," in the sense of a fuel that the body can use.

We have seen that alcohol is not stored by the body. There remains to be considered the extent to which it can replace each of the ordinary food-stuffs.

How far alcohol can replace ordinary food-stuffs :

(1) *Carbohydrates.*

Experiments of the kind described above have shown that, up to a certain point, carbohydrate can be replaced by alcohol. A man was kept on a standard measured diet, rich in carbohydrates, and his respiratory quotient was carefully determined. A ration of alcohol was then added to the diet. The respiratory quotient fell promptly and to such an extent as to show that, while the alcohol was being oxidised, carbohydrate was being saved from oxidation and added to the fuel reserve of the man's body.

(2) *Fats.*

All those who have made experiments on the point, agree in finding that alcohol can take the place of part of the fats in a diet. If a fixed diet, sufficient for maintenance, is given, the addition of alcohol to it protects some fat from oxidation, and allows more fat to be added to the body's reserve supply.

(3) *Proteins.*

The case of the proteins is peculiar. They contain nitrogen, and a small proportion of sulphur, in addition to carbon, hydrogen, and oxygen, and, as stated above, the animal body can obtain the materials for repairing the wear and tear of its proteins, only from proteins in

the food. Neither carbohydrates, nor fats, nor alcohol can replace in the food the protein needed for this purpose. But an ordinary diet contains protein much in excess of this minimum needed for repair, and this excess is oxidised to furnish energy. The amount of protein which is thus being burnt can be estimated by determining the substances containing nitrogen which leave the body in the urine.

When protein alone is given as a food, the body destroys such a large proportion of it, that a large amount of it must be given; otherwise, the body loses more nitrogen in the urine than it receives in the food—an indication that the natural wastage of the body's own protein is not being made good. But if fat or carbohydrate is given in addition, the proportion of the food protein which is thus burnt is much reduced, so that a larger proportion is available for repairing the waste of the tissues, and a smaller ration of protein suffices.

The question which we have now to consider is whether alcohol can also act in this way. And it will be clear that we are not discussing whether alcohol can take the place of protein, for nothing can truly do so; the question is whether alcohol can act like carbohydrates and fats in economising protein, by reducing to a minimum the amount which the body requires. The general result of experiments made to determine this point shows that it can.

The method of experiment is to put the subject on a mixed ration, containing known amounts of protein, carbohydrate and fat. A daily determination is made of the nitrogen lost in the urine on this standard diet. The diet is so adjusted to the needs of the subject that a reduction of the carbohydrate or fat will lead to the burning of more protein, which will be indicated by the loss of more nitrogen in the urine. But instead of merely reducing carbohydrate, the effect can be tried of sub-

stituting for it a chemically equivalent amount of alcohol. For example, the original diet may contain a high proportion of sugar; a large part of this can be dropped, and a corresponding ration of whisky given instead. If this change does not cause the appearance of more nitrogen in the urine, we have evidence that the alcohol is acting like the sugar as an economiser of protein.

Most observers who have used this method are agreed that alcohol can act like a carbohydrate in this respect also, the amount of protein burnt in the body remaining just the same after the change from carbohydrate to alcohol. Others have found evidence of an increased destruction of protein when the change is made, and have, therefore, maintained that alcohol has not the same power as the carbohydrates have of saving protein. There is good reason to believe, however, that this result was due to the fact that the subjects of these experiments were not accustomed to taking alcohol, and it seems to be clearly established that, in those who are used to it, alcohol in moderate quantity is as efficient as carbohydrates or fats in reducing the amount of protein required by the body to maintain itself, by saving the proteins from being used merely as a source of energy.

Has alcohol a special action on nutrition?

Reference has already been made to the presence in an efficient diet of traces of so-called "accessory substances," which are not themselves foods, but have a profound influence on the power of the body to nourish itself on the true food-stuffs. It is necessary to discuss whether alcohol has, apart from its food-value in the sense already defined, any such specific stimulant action on nutrition. Medical opinion formerly attributed to alcohol an effect of this kind; certain wines and beers especially were credited with specific value in the "building up of the constitution," and were widely prescribed in cases of

malnutrition, such as that due to tubercular infection. This view is no longer widely held by medical men, but appears still to be current as an article of popular belief. There are probably many who regard abstinence from alcohol as incompatible with the development and preservation of a robust and vigorous bodily habit. Accurate observations lend no support to such a belief. The fuel value of alcohol, within limits, is no less than that of a corresponding quantity of sugar or lard; but, on the other hand, there is no evidence for its ever being greater. If sufficient food is being taken in other forms, the addition of alcohol to the diet may lead to the accumulation of fat, but it will not improve the nutrition. When wine or beer aids recovery after a wasting disease, it does so because the food taken in ordinary forms is not adequate. In such circumstances, the alcohol is of some use in increasing the food-value of the diet; but its main effect is probably in making the patient more comfortable and contented, and thereby improving his appetite for ordinary foods. This is not a special action on nutrition, but a drug action, which will be considered in a subsequent chapter.

Summary.

It will be useful now to summarise the conclusions which seem to be justified by the evidence discussed in this chapter, and to consider their practical bearings.

(1) Alcohol is completely and rapidly absorbed from the stomach and intestine, and distributed by the circulating blood to the different organs of the body. The rate of its absorption is modified by a number of conditions, being more rapid when alcohol is drunk in concentrated form than when drunk in dilute solution, more rapid when it is taken on an empty stomach than when taken with or soon after a meal, especially a meal with fatty constituents, and more rapid also when drunk as distilled spirits than when taken in the form of stout.

(2) A variable but always small proportion of alcohol escapes unchanged in the breath and urine. The rest is slowly oxidised (burnt) in the body, disappearing from the blood at a uniform rate of about 0.185 c.c. per kilogramme of body weight per hour. None of the alcohol is known to be converted into any substance which the body can retain.

(3) The concentration of alcohol in the blood rises for a few hours after it has been swallowed, and then steadily declines. The duration of these phases is modified by conditions affecting either the rate of absorption or the rate of disappearance.

(4) The energy liberated by the combustion of a moderate amount of alcohol can be used by the body to its full value.

(5) Alcohol can, within limits, replace an equivalent amount of carbohydrate or fat in the diet, and has a similar effect to that of these food-constituents in economising proteins.

(6) The whole food-value of alcohol is due to its use by the body as a fuel.

Food-value of alcohol qualified by its drug action.

The conclusions thus summarised are concerned with the purely scientific question, whether alcohol acts as a food in the sense here defined. The question whether a substance is a desirable constituent of a diet, whether its use is advisable, is a much wider one than this, and involves many considerations other than that of the body's ability to use it as a fuel. There are other substances which the body oxidises as completely as it does alcohol, such as citric or acetic acid (the acids contained in lemon juice and vinegar respectively). Nobody would suggest that either of these substances could be taken in such quantities as to make a material contribution to the fuel required by the body. In practice they are not so taken, being used only in small quantities, for their acid taste and not for their food-value. Their other

properties make it impossible to take them in large quantities. Theoretically they are foods ; practically their value as such is negligible.

Similarly, in discussing the evidence for the action of alcohol as a food, it has repeatedly been necessary to use qualifying expressions such as " within limits," " in moderate quantities," etc. These limits are, of course, imposed by the other effects of alcohol, which will form the subject of the ensuing chapters. The question as to how far the theoretical value of alcohol as a food is in practice restricted and counterbalanced by these other properties, must be left till they have been considered. It is desirable here, however, to emphasise the fact that, for the normal man, alcohol has no advantage over an ordinary food-substance like sugar, from the point of view of its food-value alone. The question of its food-value cannot, therefore, be allowed much weight in the practical decision of the individual as to whether he should or should not take alcohol. This question must be decided rather by a balancing of the advantageous features of what is here termed its " drug-action " against those which are undesirable, and against the risk of the wholly bad effects included under its action as a " poison."

CHAPTER III.

Mental Effects of Alcohol.

Effect of environment on symptoms of drunkenness.

The aspect of drunkenness which has most impressed the popular mind is that of boisterous, disordered and even violent activity of mind and body which not infrequently appears as one phase of the process of intoxication. But this phase commonly appears under social conditions which stimulate the emotions; alcohol undoubtedly diminishes the control of the intellect and the will over the emotions, and it appears not improbable that this passing phase of excitement may be sufficiently accounted for by exciting influences of the environment, the jovial company, the bright lights, the unrestrained talk and song, the general sense of festivity, which are the common setting of the feast. The conclusion indicated by laboratory tests of mental and bodily capacity is borne out by simple observation of one's self or of other subjects, if one takes successive doses of alcohol in the absence of all such exciting influences. The first effect generally noticed is a slight giddiness or "light-headedness"; this is followed by an increasing heaviness and disinclination for all effort, soon passing into sleepiness; and this in turn, if not counteracted by any excitement coming from within or without, gives place to a heavy sleep which continues for many hours.

Feeling of well-being induced by alcohol.

We may notice at once that even under these conditions alcohol produces to some degree that effect which, perhaps more than any other, is the secret of its charm, its well-nigh universal attraction for the human race, namely, a sense of careless well-being or of bodily and mental comfort. In so far

as this sense of well-being is of bodily origin, it is no doubt largely due to a flushing of the skin with blood that abolishes all sense of chill ; but it is due also in part to a blunting of the sensibility to the small aches and pains and a thousand hardly distinguishable sense-impressions which, except in those in perfect health, contribute to tip the balance of bodily feeling-tone to the negative or unpleasant side. In so far as this effect is primarily mental, it results from the blunting of those higher mental faculties which lead us to " look before and after and pine for what is not " and harass us with care for the future and a too sensitive self-consciousness for the present.

Appearance of excitement not due to any stimulant action of alcohol.

If, on the other hand, the drinker is subjected to the stimulation that comes from social intercourse he usually passes through a phase which may be justly called one of excitement, the degree of excitement depending upon the temperament of the drinker and the nature and degree of the external stimuli. But careful observation of and reflection upon the phenomena of this stage show clearly that they do not require for their explanation the assumption that alcohol stimulates the nervous system, whether directly or through the medium of other bodily organs.

The drinker's conversation and actions become less restrained ; all his emotional responses are freer and fuller than in his normal state. He laughs and smiles more readily, he grows more easily angry or tender, elated or depressed, scornful or compassionate, according to the appeal of the moment. Perhaps the various emotional states into which fear enters as an element, and which we denote by such names as anxiety, worry, care, despondency, are exceptions to this rule. This group of exceptions is readily explicable on the principle that we apply, namely, that

alcohol successively weakens and suspends the hierarchy of functions of the brain, and therefore of the mind, in the order from above downwards ; that is to say, in the inverse order of their development in the individual and in the race. For the emotional dispositions or capacities are a very ancient racial endowment and have their physiological seats in the basal ganglia, the lowest levels of the great brain, the part which alone is represented in the brains of the lower vertebrates. The higher intellectual faculties, on the other hand, are the latest acquired and are connected with the anatomically highest and last developed parts of the brain. Intermediate between these come, in the order of development, the sensory and skilled motor functions (and their nerve centres).

Blunting of self-criticism by alcohol.

Now, of all the intellectual functions, that of self-criticism is the highest and latest developed, for in it are combined the functions of critical judgment and of self-consciousness, that self-knowledge which is essential to the supreme activity we call volition or the deliberative will. It is the blunting of this critical side of self-awareness by alcohol, and the consequent setting free of the emotions and their instinctive impulses from its habitual control, that give to the convivial drinker the aspect and the reality of a general excitement.

In the mature, well-developed mind this interplay of thought and emotion goes on under the checking and moderating influence of self-criticism ; in social intercourse especially, it is constantly checked by the thought of the figure one cuts in the eyes of one's fellow men. In proportion, then, as alcohol hampers this mechanism of self-control, the liberation of intellectual or emotional effects goes on at a higher rate. Normally the emotional states of anxiety, care and despondency are maintained by self-consciousness, by the repeated turning of the stream of

thought to the self, its difficulties, its embarrassments, the snares and dangers that beset its course on every hand, and are far more frequently imagined and foreseen than actually encountered. Hence, when imaginative self-consciousness is dimmed, the emotions of this class are proportionately less liable to be touched to life, and in the absence of their restraining influence, the other emotions run riot the more gaily.

Weakening of self-control evident in every stage of drunkenness; most prominent feature of initial stage.

Both introspectively and objectively this lack of self-control is clearly discernible in every stage of alcoholic intoxication. It is commonly counteracted in part by the subject, who becomes aware of it, by means of a deliberately increased effort of self-control; but, as the influence of the alcohol increases, this effort ceases to be continuously effective, and the drinker surprises the observer (whether himself or another) by smiling or laughing aloud at some very small joke, or by remarks or other actions which betray the suspension of his habitual self-control. And the weakening of his critical self-awareness is especially revealed by the fact that such jovial remarks as he now utters seem to him to shine with a lustre hardly perceptible to the normal mind; hence the tendency, perhaps the most characteristic and constant feature of the first stage of drunkenness, to flippant whimsical utterances, which, like the rest of the subject's behaviour, betray the blunting of his critical self-consciousness and of his sense of personal responsibility.

The successive stages or phases of intoxication cannot be sharply distinguished, and every case presents its peculiar combination and succession of features, varying with the temperament and disposition and character of the individual and his circumstances of the moment. But three main stages may be broadly distinguished correspond-

ing to the invasion by the narcotic of the three principal levels of cerebral function mentioned above. The first stage, that in which the highest or intellectual brain level is alone distinctly affected, has been described above.

Nervous functions involved in second stage of drunkenness.

The second stage is that in which the functions of the intermediate level, sense-perception and skilled movement, are invaded and disturbed. The drinker begins to show a certain clumsiness of behaviour. If he is self-observant, he notices that he is liable to make ill-adjusted movements ; on setting down his glass it makes a more violent contact with the table than he had intended ; on rising, he may stumble against a chair, perhaps upsetting it ; on lighting a cigarette he may break the match which he essays to strike ; in speaking he may slur a word or drop an *h*. Each such little mishap will at first be quickly rectified, for each one may evoke the power, possessed in some degree by all and to a wonderful degree by many men, of temporarily correcting by an effort of concentration or self-control the paralysing effects of the drug.

Emotional instability in second stage of drunkenness.

At this stage also his perceptions are impaired. His field of sense-observation is narrowed ; the several senses work in relative isolation from one another ; the fineness of his ear, of his taste, his touch, his vision is blunted ; he may momentarily see objects doubled, and becomes relatively indifferent to heat and cold, to the flavour of his food and the aroma of his wine, to the glare of the lights, the strains of the music, and the stridency of his own or his neighbour's voice. The impairment of his intellectual functions being further advanced than in the first stage, and the functions of the third or lowest cerebral level, that of the emotions and instinctive impulses, being

still relatively intact, he is apt to give way to clumsy but violent displays of emotion characterised by the exclusive dominance of each primary emotion in turn ; and he passes quickly from anger to affection, from boisterous merriment to tears, from elated boasting to despondency, each unrestrained and unmodified by that blending of other emotions which expresses the reaction of the intellectual faculties upon them.

At this stage the drinker is apt to feel that his bodily movements occur without his initiation or intention—they escape from him rather than proceed from his will—and, in so far as he remains self-conscious, he leads a double life ; his inner self, a detached observer with folded hands, watches his bodily actions, not seldom with surprise, consternation or amusement ; he may, *e.g.*, become aware of wearing facial expressions, of making gestures, or of uttering remarks, which he did not intend and cannot wholly repress, but which seem to him to be executed by his members of their own initiative.

At this stage the paralysis of the drinker's higher mental functions reveals itself clearly also in the increasing dependence of all mental and bodily activity upon external stimulation ; he lives in and for the present moment only, and, if he is deprived of the stimulus of social intercourse, he quickly lapses into dreamy somnolence or actual sleep.

Third stage of drunkenness.

In the third stage, the intellectual processes of judgment and self-criticism and control are virtually suspended ; the functions of sense-perception and skilled movement are grossly impaired, and the emotional tendencies themselves are invaded and weakened, so that only strong appeals to them suffice to evoke any response and, in their absence, the drinker sinks inert and nerveless into a heavy sleep, which lasts until the alcohol absorbed has all been oxidised.

Hypothesis that alcohol acts primarily on nerve-cell junctions or synapses.

This succession of events, constituting the normal course of alcoholic intoxication as it appears to common observation, can be explained in general terms by an hypothesis as to the direct action of alcohol on the nervous tissue, which is suggested and supported by many physiological facts and analogies; the hypothesis, namely, that alcohol acts primarily and most powerfully not upon the nerve cells or fibres, but upon the junctions between nerve-cells, technically known as *synapses*. It is now pretty well established that we may properly regard the nervous system as consisting of a vast number of vital units, the nerve-cells, each consisting of a central body and one or more slender threads or fibres; each cell having no anatomical but only a functional continuity with others. Their relations to one another may be likened to those of a crowd of people, in which each person maintains relations with his fellows and communicates with them only by the touch of hands and feet. There is much evidence to show that these points of contact are the weak points of the nervous pathways; the points that give way most readily under strain or shock and under the influence of fatigue and of various paralysing drugs.

Why effects of alcohol are first shown on higher functions.

Further, there is good reason to believe that in the pathways of the lower levels of the brain, those which subserve the functions first developed in the race and in the invididual, the points of junction are relatively firm and open to the passage of the nervous current; while those of higher and later developed levels are less solidly organised, and that they therefore offer more resistance to the passage of the nervous current, in proportion as they stand high in the scale of function and

late in the order of development. If we accept this view, and if we make the further simple assumption that alcohol acts equally upon all such junctions of nerve-cells (or synapses), we have the explanation of the phenomena of drunkenness. For, by the terms of the hypothesis, the alcohol, acting equally upon all cell-junctions in the nervous system to increase their resistance to the passage of the nervous current, will first raise this resistance to the point of impermeability in those junctions in which it is normally highest, that is, in the latest developed paths of highest function ; and it will progressively effect a similar paralysis of other nerve-paths in the descending order of functional dignity and complexity.

Action of alcohol purely narcotic.

It may be added that a review of the many laborious attempts made in recent years to determine by the methods of the laboratory the effects of alcohol on the mind and nervous system, shows that such observations harmonise well with these general conclusions ; for, although some of the earlier workers on these lines believed they had found evidence of an initial stimulating effect of alcohol, this appeared in all cases to be of but small extent and duration ; and later work throws doubt upon the validity of this interpretation of the evidence and supports the conclusion that the direct effect of alcohol upon the nervous system is, in all stages and upon all parts of the system,* to depress or suspend its functions ; that it is, in short, from first to last a narcotic drug.

Varieties of mental symptoms in drunkenness.

If we have truly stated the principle according to which alcohol attacks the functions of the brain and of the nervous system generally, it will be seen that mental changes are naturally among the first of all the symptoms of derange-

* For a possible exception to this statement, in the case of the nerve centres of respiration, see pp. 75-76.

ment to appear. With small doses of alcohol, they may be the only symptoms which are noticeable ; with larger, they are the earliest of the whole symptomatic train of changes. It is obvious that, though traceable by psychological analysis to one single source, namely the blunting of that intellectual self-criticism and control which the mind normally exerts, the detailed forms which they assume will, under the manifold varieties of individual circumstance and character, appear as disordered items of behaviour almost Protean in shape and kind. Yet of these, various as they are, certain sub-types appear with such frequency, and have been so accreditably documented in carefully conducted test experiments.* as to be worth specific mention here, since they can be regarded as established marks symptomatic of alcoholic effect. In this respect they have therefore some practical importance. They may be subsumed briefly thus : (1) Uncritical self-satisfaction of the subject with his own performances, (2) disregard of occurrences and conditions normally evoking caution of act and word, (3) trespass of rules and conventions previously respected, (4) impaired appreciation of the passage of time, (5) loquacity and (6) an argumentative frame of mind.

Early appearance of purely mental effects of alcohol.

These changes of mentality actually observed in laboratory experiments directed toward study of alcoholic effect are largely confirmed by general experience. As laboratory experiments show, they may occur when the dose and degree of action of the alcohol are quite insufficient to cripple manifestly and openly the power to perform routine technical operations, such as adding figures or typewriting by a person accustomed to perform them. To attempt to

* Kraepelin. Über die Beeinflussung einfacher psychischer Vorgänge durch einige Arzneimittel. Jena, 1893. Rivers. Influence of Alcohol and other Drugs on Fatigue. London. 1907. Partridge. Studies in the Psychology of Intemperance. New York, 1912.

specify the lower limit of dose required to produce these symptoms is probably of little value. Not only is there varying susceptibility to alcohol from person to person, and not only does, in one and the same person, the susceptibility differ according to circumstances, digestive and other, under the same dose, but intellectual self-criticism and control are strong in one person, weak in another, and, in the same person, while strong in respect of certain kinds of acts, may be weak in respect of certain others. With large doses these slighter mental effects are part of the train of symptoms passed through, as profounder degrees of intoxication are approached.

Disturbance of higher mental functions in conditions falling short of drunkenness.

But a point of greater practical importance is that, without signs of intoxication in the full ordinary or in the legal sense of the term, the bearing and individual attitude of mind suffer temporary change as an effect of the drug; and those in contact with the person so affected have for the time being to deal with an altered individual, whose mind lacks temporarily its normal factor of judgment and conspicuous elements of its self-control.

There is hardly any need to emphasise here the obvious fact, that the directions which these alterations tend to take commonly, even as instanced merely by the few subtypes of deviation of judgment and behaviour just mentioned, are likely to be fraught with serious consequences for the due discharge of responsibilities in all walks of practical life. Accuracy, avoidance of accidents, tactful handling of colleagues and subordinates, observance of discipline, punctuality, reticence in matters of confidence, are all obviously jeopardised; and an additional source of friction is brought to complicate the relations between the employer and the employed.

CHAPTER IV.

Alcohol and the Performance of Muscular Acts, and of the Simpler Mental Processes.

In the preceding chapter we have dealt with the effects of alcohol on the general complexion of the mind and on behaviour. A number of experimental enquiries have been carried out on the effects of alcohol on muscular activities, and on such simple mental processes as are susceptible of quantitative measurement in the laboratory. It will be convenient to group these together in this chapter, since, in more than one instance, the same observer has applied, to the same individual, tests which comprise measurements of skill or endurance in the performance of some co-ordinated muscular movement, measurements of the efficiency of purely mental processes, such as rapidity and accuracy in memorising, and again tests in which it would be difficult to decide whether the mental process or the neuromuscular co-ordination was the more important factor in the result.

Complexity of muscular acts.

The effect produced by alcohol on the performance of muscular work is not so readily determinable as might at first sight appear. The performance of a muscular act, even of a simple kind, involves a number of processes. The actual contraction of the muscle is only the final step in a series of events. The action of the muscle has invariably to be called forth by recurrent nervous action, and this nervous action includes, even in the simplest voluntary act, a linked series of processes with which many parts of the nervous system are concerned.

Influence of alcohol on their performance due to action on nervous system, and not on muscles.

The muscle being the final executant of the act, a point needing elucidation is how far the administration of alcohol influences directly the functioning of the muscles themselves. The muscles differ sufficiently from the organs of the nervous system to make it probable that the influence of alcohol on the two will not be the same, at least, not of the same magnitude.

The influence of alcohol upon muscles separated from the nervous system has been examined, and it has been found that when administered to them through the blood in doses up to the equivalent of about 70 cubic centimetres in man or nearly 5 oz. of whisky at proof strength,* alcohol produces no obvious effect upon the contractile power or other functional properties of muscle.

We may infer then that any influence which alcohol, in such doses as are met with in ordinary human consumption of it, exerts upon the performance of muscular acts, must be referred to its effects upon the nerve centres concerned with activating the muscle.

Reflex acts and volitional acts.

The nervous processes which find their expression in muscular acts, are divisible into two main kinds. Those of one kind are termed volitional, because produced at the behest of the will; of the other, involuntary, because independent of the will. The former, even at their simplest, are complex. The latter, often spoken of as "reflexes," are less so. These latter are for this reason more completely understood and analysed; the nervous events involved in them are sufficiently known to serve as standards by which the effect of alcohol upon

* V. Furth and C. Schwarz, Pflüger's Archiv. f. d. ges. Physiologie, Vol. 129, p. 525. 1909.

certain fundamental processes of nervous activity can be gauged. The relative simplicity of the reflexes has made it possible for medical study to ascertain with exactitude what parts and elements of the nervous system are required for their performance and to judge from them whether those parts are working well or ill. Changes in them give fairly precise information as to the seat and manner of any improvement or impairment they may show. They are of importance further, since it is by means of the nervous centres which the reflex acts use that volitional nervous acts, initiated in the higher nervous centres, exercise their effect upon their executant muscles. Skilled movements of hand and arm, executed under the mandate of the will, demand for their performance the employment by the brain of those same lower centres which the reflexes of the limb employ and test. The brain centres bring the muscles into action through the lower reflex centres.

If for some part of the body, say leg or eye, these latter are deranged, it is not to be expected that the skilled execution, by that part, of acts under the behest of the will can continue to be perfect or normal.

Influence of alcohol on simple reflex action.

(*i*) *The knee-jerk.*

A simple reflex act, much used by the physician for testing the healthy working condition of the spinal cord, is the knee-jerk. A light tap is dealt to the front of the knee just below the knee-cap, on the tendon of the muscle that straightens the knee. The tap is delivered at a time when the limb is at rest, for instance when one knee is passively resting crossed upon the other. This light blow stretches slightly and briefly the muscle, and this slight stretch excites nerve-fibres which pass from the muscle to the nerve-centres in the spinal cord, and so excites these centres. The centres in their turn excite the muscle by

means of the motor nerve passing from them to it. This causes the jerk-like movement of the knee. This reaction tests therefore, (*i*) the nerves passing from the muscle to the spinal centres and from the latter to the muscle; (*ii*) the spinal centres themselves; and (*iii*) the muscle. It gives reliable indications not only of the healthy or disordered condition of these parts, but in several respects also of the condition of the brain itself as influencing that of the spinal cord. The indications it yields are the more valuable because it is a reflex which lies beyond the voluntary control of the person examined. It cannot be quickened or slowed, increased or diminished at will by the person experimented on.

Experiments conducted by Dodge and Benedict* showed that a dose of 30 cubic centimetres of alcohol, equivalent to a little over 2 oz. of whisky at proof, or to about 1¼ pint of beer of average strength (*i.e.*, containing 4 per cent. of absolute alcohol), administered an hour to an hour and a half earlier, lessened the speed and amplitude of the movement of the knee-jerk in healthy persons. As an average obtained from observations on six men, this dose of alcohol reduced the speed of commencement of the responsive movement by 9.6 per cent. and diminished the extent of the movement by 48.9 per cent. A larger dose, 45 cubic centimetres of alcohol, in the same persons impaired the reaction speed and amplitude still more.

These experiments were repeated by Miles.† He also found that the speed of the knee-jerk was lessened during the first 2¼ hours after a dose of 30 c.c. of alcohol. Subsequently the speed was somewhat increased. The effect of alcohol on the amplitude of the movement was irregular.

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* Dodge & Benedict, Psychological Effects of Alcohol, Washington, 1915.

† W. R. Miles. Effect of Alcohol on Psycho-physiological Functions —*Carnegie Institute of Washington*, 1918.

(ii) The "eye-closing reflex."

Another reflex, somewhat less simple, is the "eye-closing reflex." The movement is an involuntary blink which occurs when some local danger imperils the eye, as when grit enters it or a blow threatens it. It commonly occurs also when some startling shock is received by the body, or when a loud, sudden, unexpected noise is heard. Although it is an involuntary act, repression of it can by practice and training be acquired in regard to circumstances which otherwise regularly evoke it. Thus, as a response to a threatened blow or to a sudden loud noise, those who are practised in boxing and in the use of firearms learn to suppress it.

The effect of alcohol on this reflex has been examined by Dodge and Benedict* in the six normal men whose knee-jerk was tested as above. The dose of 30 cubic centimetres of alcohol retarded the reflex speed by 5·9 per cent., taking the average from four of the men; it decreased the eyelid movement's extent by 10·7 per cent., taking the average measure from five of the men. 45 cubic centimetres of alcohol, equivalent to about 3 oz. of whisky at proof, or to nearly 2 pints of beer, impaired the reflex still more. In two of the men the smaller dose slightly increased the reflex-speed, and in one of these two the larger dose also increased it. The means used in these observations for evoking the eye-blink reflex was the sudden production of a loud, noise. Both of the men in whom the dose of alcohol induced increase in the speed of the reflex were found normally and apart from any dosage with alcohol to exhibit unusually small blink-reflexes. The observers concluded that the normal blink-reflex in these two men was a partially restrained one, some degree of inhibitory control over the reflex having been acquired by them. One of them was practised in boxing and

* Dodge & Benedict, op. cit., 1915.

one in revolver shooting. The observers concluded that the quickening of the reflex produced in these two cases by the alcohol was due to the alcohol weakening the acquired inhibitory control.

Miles found that 40 minutes after a dose of 30 c.c. of alcohol the speed of the movement was decreased by more than 12 per cent. on an average. The speed gradually increased till $2\frac{1}{4}$ hours after the dose it was somewhat greater than normal; it then again became less. The extent of the eyelid's movement followed the same course as the speed.

Depressant effect of alcohol on simple reflexes.

This dose of alcohol, therefore, depresses these simple reflex reactions of the nervous system. Even in regard to the somewhat greater frequency of the pulse-rate which commonly follows the administration of a moderate dose of alcohol, the cause seems to lie in a depressant rather than a stimulant action of the drug. The acceleration of the pulse appears to be due to depression in degree of the reflex cardio-inhibitory tone which normally restrains the heart beat.* The depression caused by the alcohol in all these instances indicates a specific lowering of the powers of the lower nervous centres, of a nature resembling, though much less in intensity, that produced by chloroform and drugs of that kind, tending towards temporary paralysis.

Difficulty of analysing effect of alcohol on volitional acts.

Simple reflexes like the above form a suitable starting point for inquiry into any influence which alcohol may exert upon the nervous system in its performance of muscular acts. But the step from such simple reflexes to acts initiated and controlled by the will is a considerable one into a region of greater complexity. Besides the

* Dodge & Benedict, op. cit., 1915.

lower reflex centres through which the volitional processes must ultimately play, the nerve-centres concerned in calling forth and directing a muscular act at behest of the will are many, some in the highest parts of the brain and others in the lower, and some in the spinal cord itself. It is impossible to track the influence of alcohol step by step through such a maze. But it can be said with certainty that the degree of action of the alcohol will not appear equally in all the centres nor in all the phases of their processes. The detailed nature of the normal interaction of the various centres, whence the willed muscular act results, is far from being as yet sufficiently known to justify here an attempt to analyse the influence of alcohol on the separate steps of the process.

Effect of alcohol on efficiency of willed movements.

Experiments have however been made which, without attempting to analyse the willed act, and accepting the movement made as index of its success, indicate how its efficiency changes with varying conditions. Three main directions in which the efficiency may vary are (1) in power, (2) in ability to withstand fatigue, and (3) in nicety of adjustment for the object in view. The power of a muscular act and its ability to withstand fatigue can be examined by the ergograph. This instrument registers the strength and extent of a particular willed movement which can be easily repeated, the instrument continuing its register throughout a series of repetitions of the act. The movement arranged for is purposely kept a very simple one, and therefore little scope is given in the ergograph for examination of nicety of adjustment, or other factors which constitute "skill."

Ergographic experiments on the effect of alcohol.

The influence of alcohol has been examined ergographically by many observers. Some of the observations

appear, however, to be of small value for our purpose ; in some the dose of alcohol is unstated ; in some the form of ergograph was unsatisfactory ; in some too little heed was paid to circumstances, other than the giving of alcohol, likely to influence the muscular act under the conditions of the experiment. The earlier observers, impressed with the simplicity of the actual movement employed as an index, did not appreciate fully the extent to which mental conditions might affect it. Experience with ergographic records has shown that fleeting states of the mind, greater or lesser concentration of attention or greater or lesser interest in the repetition of the movement at one time than at another, may influence quite distinctly a person's performance of a movement even so simple as that chosen for the ergograph. Mental "suggestion" has to be excluded so far as possible from disturbing the subject's attitude toward the experiment, which should be a neutral attitude. The mere knowing that he has or has not received a dose of alcohol may affect his performance under the test and obscure or confuse any effect produced by the alcohol itself.

The researches in which precautions have been taken definitely to safeguard against these various sources of error are still relatively few, and notable among them is the investigation by Rivers.* Rivers found that single doses of 5, of 10, and of 20 cubic centimetres of alcohol left no indubitable trace upon the muscular act, as recorded by the ergograph. His experiments were carried out upon two persons. When the dose was increased to 40 cubic centimetres, corresponding to over $2\frac{3}{4}$ oz. of whisky, or to about $1\frac{3}{4}$ pint of beer, an effect was produced on one of these. That person was habitually an abstainer from alcohol. The effect produced on his ergograph record

* Rivers. Influence of Alcohol and other Drugs on Fatigue, London. 1907.

was increase in the series of contractions performed, this increase appearing about an hour and a half after the administration of the dose. The increase was small. On the other person examined the dose of 40 cc. was followed by slight decrease of the ergographic work, but Rivers was not satisfied that in the case of this person the dose produced any clearly indubitable effect.

The result stands in general conformity with results obtained previously by Oseretzkowsky and Kraepelin*, who found no obvious evidence of an effect of alcohol on the ergographic record after administration of a single dose of 50 cubic centimetres (*i.e.*, 3½ oz. of whisky or a little over 2 pints of beer).

In the extensive series of ergographic experiments by Hellsten†, the ergograph employed was of an unusual type, the movement registered being executed with both arms, and therefore not so limited and simple as is generally preferred for ergographic examination. Working with this type of ergograph, Hellsten tested the influence of alcohol upon its records. The subject of experiment was an athlete of 90 kilos (between 14 and 15 stone) weight. Single doses of 25 and of 50 cubic centimetres of alcohol, given in appropriate dilution with water 5-10 minutes before the ergographic record began, produced no close and unequivocal effect on the record. When the dose was 80 cubic centimetres, corresponding to between 5 and 6 ounces of whisky, or more than 3 pints of beer, there ensued, after a slight and brief-lasting improvement in the record, a marked decrease in the recorded muscular work. When this dose preceded the test by half an hour, the decrease observed amounted to 20 per cent. of the normal performance done without alcohol. The decrease

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* Oseretzkowsky u. Kraepelin, in Psychologische Arbeiten, Vol. 3, pt. 4, p. 587: 1901.

† Hellsten. Skandinav. Archiv. f. Physiologie. Vol. 16, p. 160. 1904.

was 17 per cent. when the dose preceded the test by one hour, and was 11 per cent. when it preceded the test by two hours.

Animal experiments to test effect of alcohol on work.

Comparable in some measure with the above experiments are those carried out by Chauveau,* who examined the influence of alcohol upon the output of work by a trained dog turning a treadmill. The dog had a measured and liberal daily ration of raw meat and cane-sugar. When one-third, namely 84 grammes, of the daily sugar ration was replaced by 50 cubic centimetres of alcohol the output fell by about 22 per cent. Similar results were obtained whether the alternation of the rations followed weekly or monthly. The dog lost weight on the alcohol substitution ration and maintained its weight on the ration without alcohol. The actual weight of the dog is not stated, but the daily amount of alcohol taken by it in the substituted ration must have been equivalent to not less than 250 cubic centimetres alcohol for a man, or not much short of a pint of whisky. Dogs are, however, less susceptible to alcohol than is man.

Observations on effect of alcohol on efficiency in hill-climbing.

Comparable also to some extent with these observations on the dog are observations by Dürig† upon man. Dürig observed the effect of alcohol upon the muscular exercise involved in walking to the top of a hill. The ascent and the route taken and the time of day and other conditions of the ascent were kept as far as practicable the same for a number of successive repetitions, with the exception that on some days 30 cubic centimetres alcohol in 150 cubic centimetres of water, *i.e.*, as much alcohol as is contained in

* Chauveau. Comptes rendus de l'Académie des Sciences. Vol. 132, pp. 65 and 110. 1901.

† Dürig. Pflüger's Archiv für die ges. Physiologie. Vol. 113, p. 314. 1906.

2 oz. of whisky or 1¼ pint of beer, was taken in addition to the daily ration. This dose was taken at breakfast just before starting. It was found that although the walker, who was accustomed to moderate use of alcohol, felt in himself no difference between his condition on the alcohol and non-alcohol days, the distance and ascent per minute was on the alcohol days less by 12-14 per cent. than that on the non-alcohol days. This was so, although the expenditure of energy by his body was greater on the alcohol days than on the non-alcohol days. Dürig inclined to attribute this deterioration in the performance of the ascent to impairment of skill with which movements are directed. He says that it was as if the effect of previous training in the act were temporarily lost. The experienced climber is reduced by the dose of alcohol towards the level of a beginner at such work and makes an unduly large number of badly directed or ill-judged movements. In short, alcohol in a dose of 30 c.c. tended to undo the effect of previous training. The act here was of course much more complex and gave much more scope for skill than the acts examined by the ordinary ergograph.

Disturbing effect of alcohol on skilled movements.

Rivers, in an appendix to the account of his ergographic observations, notes that, although the ergographic records showed, even when the dose of alcohol was 40 cubic centimetres, slight evidence only of their being influenced by it, there was from the experiments other evidence to the effect that after that dose " the control of movement did not appear to be so good," and that the execution of movements tended to be slower than usual. His evidence for this is as follows :—" In the normal condition," *i.e.*, of the subject experimented upon, " the two minutes allowed him between successive ergograms for taking the customary readings and for making necessary adjustments of the ergograph were ample for his doing so ; but on the 40 c.c.

alcohol days the period of 2 minutes was hardly long enough for him to do what was necessary, although the time it took him seemed to him no longer than usual. This was so striking that the subject was at first inclined to believe that his watch was in error, for it seemed to him that he had been carrying out his usual task at the normal speed."

" Several small accidents happened on days on which the dose of alcohol was 40 c.c., and these were probably the result of awkwardness in adjusting the apparatus. Some of the intervals " (between the actual spells of exercise at the ergograph) " were occupied " (by the subject) " in drawing lines for tabular purposes or in pasting ergograms in a book, and these operations were found afterwards to have been done roughly or irregularly on the 40 c.c. alcohol days."

Experiments designed for the special purpose of testing the effects of alcohol on the accurate co-ordination of nervous and muscular activity which is necessary for skilled movements have been carried out by Vernon* and by McDougall and Smith.†

McDougall and Smith studied the effects of alcohol on persons in a normal condition and when unduly fatigued by enforced lack of sleep. They employed the " dotting machine " and a simple memory test. The dotting machine is an apparatus by which a paper tape about 1 inch wide is made to pass before the subject by clockwork. The subject sees at any moment only as much of the tape as appears behind a small window in the top of the machine. On the tape is printed an irregular line of small red circles and the subject attempts to make a dot in each circle as it passes the window.

The results showed that more mistakes were invariably

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* *Medical Research Committee, Special Report, No.* 34, 1919.

† *Medical Research Committee, Special Report, No.* 56, 1920.

made after a sufficient dose of alcohol had been taken. The dose might be as small as 10 c.c. if taken some hours after a meal, though 30 c.c. taken with a meal had only a very slight action. The result of diluting the dose was also to decrease its effect.

The action of alcohol was the same both in the normal and fatigued condition of the subject, except during a period which can best be described as one of convalescence following much loss of sleep; during this period, alcohol had the effect of improving the results of the test.

Vernon used as tests (1) the speed and accuracy with which a short paragraph, which the subject knew by heart, could be reproduced on the typewriter; (2) quickness and accuracy in using an adding machine; (3) the "target" test. In the latter, the subject is required to prick a hole as near as possible to each of a series of dots in a piece of paper, the paper being fixed in a vertical position, at arm's length from the subject.

He found in all his subjects and with all the tests employed that the accuracy of the muscular movements was impaired after alcohol had been taken. The effects varied according to the susceptibility of the subject, the amount taken, and the conditions under which it was taken. It was found to have less effect when taken diluted or with food.

Unfortunately a large proportion of Dr. Vernon's experiments are, from the point of view of the psychologist, open to the objection that the observer and the subject were one and the same person, who, in carrying out tests involving volition and skill, knew what amount of alcohol had been taken, and was aware of the suggested influence of relation to meals, dilution, etc. The results are therefore not so convincing as they otherwise might have been, and it can only be said that they show no disharmony with those obtained under more suitably controlled condition.

Miles* employed a somewhat elaborate electrical

* W. R. Miles, *J. Exper. Psychol.* Vol. 4., p. 77, 1921.

apparatus, "the pursuit-meter." The task set the subject was analogous to that of a sailor steering a ship on a given course by compass. He has to manipulate the wheel in such a way that a certain point on the circumference of the compass card is always exactly opposite another point on the fixed framework of the compass. If the ship moves from her course, under the influence of the wind or waves, the compass card will begin to swing in one or other direction, and must be brought back by the correct movement of the wheel. The needle of the pursuitmeter, which the subject must keep steady in an analogous manner, receives impulses to swing in one or other direction in a much quicker and more irregular manner than does the compass card in a ship, and the subject has to counteract these impulses by corresponding movements of a handle. When the needle deviates from the proper position, it allows an amount of current proportional to the extent and duration of the deviation to pass through an electric meter which records the number of units passing; so that the more accurate the movements of the subjects are, the less the meter will record.

Miles found the amount of current allowed to pass by his subject after he had drunk a litre of 2.75 per cent. alcohol (approximately equivalent to 1½ pints of very light beer) was on an average about 11 per cent. more than when he had drunk the same quantity of water.

Effect of alcohol on adjustment of eye-movements.

The evidence summarized in the preceding section shows that the execution of skilled movements tends to be impaired by alcohol.

This stands in harmony with observations by Guillery* on the influence of alcohol on certain movements of the eyes.

* Guillery. Pflüger's Archiv für die ges. Physiologie. Vol. 79, p. 597. 1899.

Guillery tested the ability of the eyes to follow clearly an object brought nearer and nearer to the person observing it, that is to keep both eyes focussed on it as it approached. This requires a convergent movement of the eyeballs, the convergence increasing in degree as the object is brought closer. At a certain closeness further convergence becomes impossible and fixation is lost, the object no longer appearing single. He found that the degree of convergence possible for the person was not affected, either in the direction of improvement or impairment, by a dose of 20 cubic centimetres alcohol, equivalent to nearly $1\frac{1}{2}$ oz. of whisky, or to over $\frac{3}{4}$ of a pint of beer, but that by a dose of 40 cubic centimetres it was very distinctly impaired. The impairment took the form of weakening and of slowing of the movement. The impairment was first detectible about 20 minutes after the taking of the dose ; normal speed and power were regained about 40 minutes later. With 60 cubic centimetres of alcohol the impairment was greater, came on about 10-15 minutes after the dose and lasted for an hour and a half. The opposite movement of " divergence " was impaired even more, and other eye movements similarly examined were found also to be impaired. Guillery remarked that at no stage of the action of any dose of alcohol were the eyeball movements found to be strengthened or rendered quicker.

Similarly, Dodge and Benedict found that a dose of 45 cubic centimetres of alcohol measurably impaired the speed of starting the movement of turning the eyes toward a fresh object : in short, the speed of directing the gaze. The whole movement is one of considerable complexity of nervous adjustment. The twelve muscles of the eyeballs have all of them to act appropriately together, that is to say, some have to be made to contract more than they were contracting, others have to be relaxed from contraction, and these changes have to be made in each muscle with harmonious rate and degree. To execute

the movement the nerve centres must not only have perfect control of the necessary motor powers, but must be aware of the posture the eyeballs start from and of the direction toward which they have to be moved. These latter requisites demand the alertness of sensory nerve-centres, information from which is a factor in the guidance and alertness of the motor centres themselves.

The act is, of course, one of extremely frequent execution throughout the waking day, and from an early period of infant life onward. It is, indeed, in many respects a reflex act ; and it is under many circumstances impossible, and under still more very difficult, to repress it by the will ; it tends to occur " in spite of ourselves." A form, however, in which we meet its use in a highly practised technical act is that trained movement, learned in reading, which enables the eyes to follow the words across a page and then return correctly to the first word in the line immediately below. As with all other acts of the kind, a slight delay attends its starting, a delay which though it is not long is yet considerably longer than the delay attending such simpler reflexes as the knee-jerk. The influence of alcohol on this delay has been tested and on the same persons as those forming the subjects of the experiments on the simpler reflexes.

A dose of 45 cubic centimetres alcohol was found, an hour and a half after it had been taken, to increase the delay (average of all six men) by 15 per cent. The accuracy of the movement, that is, the degree of truth with which the eyeballs when moved hit the required direction, was not tested.

Similar experiments were carried out by Miles, who gave his subject a dose of 30 c.c. of alcohol. He found that the speed of the movement was decreased by 13 per cent. $1\frac{1}{2}$ hours after the dose was taken, and remained less than normal for a further $1\frac{3}{4}$ hours. Miles also examined the effects of alcohol on the speed of eye movements in another

manner. The subject was required to look first at one fixed point, then as quickly as possible to move his eyes on to another point, then back to the first, making as many movements as possible in 5 seconds. The effect of a dose of 30 c.c. of alcohol was to diminish the total distance moved by the eye by 21 per cent. on an average.

Effect of alcohol on speed of to and fro movement of finger.

Dodge and Benedict designed an experiment testing the performance of an act relatively simple in character yet one which is not naturally regularly practised, namely a rapid to and fro movement of a finger, the person being told to move the finger thus as rapidly as possible. The index of success taken was the speed with which the movement could be alternated, the rate at which the to and fro movements could be made to follow each other. While requiring the action of relatively lower nervous centres the exercise demands therefore in addition some effort of the higher centres in controlling and urging the former. It involves activity of the will and, though not to a high degree, demands that kind of effort which is necessary for acquiring facility in a novel manœuvre which habituation has not as yet made easy. It is therefore to this extent a test of skill, skill taking effect in speed. It tests, though very simply, just that type of nervous process which is involved in the first steps of learning to use a new tool or attaining dexterity in a new manual process.

The effect of alcohol as thus tested was examined in the same six men employed for the " turning of the gaze " test. The dose of 45 cubic centimetres of alcohol taken an hour and a half previously reduced the rapidity with which the movement could be performed by 8.8 per cent. (average of the six persons).

Confirmatory results were obtained by Miles, who found that a dose of 30 c.c. of alcohol slowed the finger movements by 3 or 4 per cent.

Effect of alcohol on memory.

McDougall and Smith, in addition to the experiments referred to above, submitted the same subjects to the following memory test. A list of forty words was read to the subject, who was afterwards required to reproduce them in the correct sequence ; each word was related to the previous word by its actual meaning, or by an alternative meaning suggested by its sound, which the subject could grasp by an act of attention, *e.g.*, mountain, plain, ugly, beauty, Venus, Greece, oil, smooth. . . .

The results agreed with those obtained with the dotting machine in that more mistakes were made after alcohol had been taken, except during the period in which the subject was recovering from fatigue.

Miles employed a memory test of a different kind. A series of twelve 4-letter words, with no connection between the meanings of successive words, was pasted to a cylinder, hidden from the subject by a screen in which was an aperture large enough to expose one word. The cylinder was made to revolve in such a way that each word in the series was made visible to the subject in succession at intervals of 4 seconds, the last letter of the word appearing first. The subject was required to read each word out aloud as it appeared. The same series of words was then exposed a second time in the same way. During the second exposure the subject was required to say each word aloud as soon as he could, either before it had started to appear or when as little as possible was showing. During both exposures an automatic record was made of the exact instant at which the subject started to say each word, and from this record could be deduced the time interval which separated the moment of complete visibility of each word and the saying of it by the subject. During the first exposure, the saying of the word followed its complete visibility and during the second, it preceded it. The sum of the two time intervals for each word was a measure of

the time saved by the subject having remembered, or partly remembered, the word; and was used as one measure of memory. Another measure was obtained by employing only the record of the second exposure and measuring the time by which the saying of the word preceded its complete visibility. Both methods of measurement gave the same result: that the memory, as tested by the procedure described, was improved after 30 c.c. of alcohol had been taken.

There is thus an apparent contradiction between the conclusions of the authors quoted, but the contradiction is explained by the fact that different forms of mental activity were tested in the two series of experiments. Whereas in McDougall and Smith's experiments each word was recalled to memory by the association of its meaning with that of the previous word in the list, in Miles' each word was recalled either because the subject remembered that it stood next to the word previously seen, or, if he had to wait till one or more letters of it appeared, by the remembered contiguity of the letter or letters so appearing to those not yet visible.

The former process is certainly on a higher intellectual plane than the latter, and as has been pointed out in the preceding chapter, the higher intellectual processes were probably the last to develop in the evolution of mind and are the first to be affected by alcohol.

Some sensory effects of alcohol.

McDougall and Smith tested the effects of alcohol with an æsthesiometer, which is an instrument designed to measure the accuracy with which tactile impressions can be localised or discriminated in different areas of the skin. It consists of a pair of compasses with blunt points, which are applied to the skin of the subject, who is then asked to say, without looking, whether he is being touched by one point or by two. The more delicate the power of

localizing sensations of touch, the more easy is it to feel the two points of the instrument as separate points. McDougall and Smith tested always the same skin area, and kept the points of the instrument 2·5 cms. apart. They found that 4½ hours after a meal the average percentage of errors before taking alcohol was 24, and after taking alcohol, 90. When, however, the test was done immediately after a meal, the effect of taking alcohol was much less, the percentage rising from 18 to 27 only.

Miles determined the " threshold of faradic stimulation," that is to say, the smallest electric shock applied to the skin which could be felt, and found that after alcohol had been taken, the strength of the electric current had to be increased before the shock could be felt.

Subjective effects of alcohol.

Rivers records with regard to the subject of his ergographic experiments—

" Within half an hour of the taking of the 40 c.c. alcohol there came on," in this person, " a subjective feeling of lassitude and disinclination for activity either of body or mind." " It was doubtful how far the state of lassitude was preceded by one of exhilaration, but, if the latter occurred, it was certainly of very brief duration." " During the state of lassitude there was decided irritability; and a fellow worker states that he was able to recognise clearly the days on which the 40 c.c. dose had been taken by the general demeanour of the subject—partly from his lassitude, partly from his very obvious irritability."

McDougall and Smith note that, after taking alcohol, their subjects felt dizzy and heavy and had difficulty in beginning any task, but on the other hand felt when doing the " dotting machine " test that they were doing it well and that the " words " in the memory test were easy. These flattering impressions were, however, not confirmed by the results of the tests, which, as shown above, were worse than normal.

Conclusions.

It will be seen that experiments suitable for yielding inferences for the present purpose are not numerous; and that, if for that reason alone, caution is necessary in making deductions from them. Yet, they agree in indicating that a single dose of less than 40 cubic centimetres of alcohol, or as much as would be taken in about $2\frac{3}{4}$ oz. of whisky at proof, or in $1\frac{3}{4}$ pint of beer, in an adult accustomed to moderate use of alcohol, exerts little or no appreciable influence on the performance by him of a muscular act of simple character not demanding precision. For acts requiring skill the inference from the experiments, so far as they go, seems, however, to be that their performance tends to be temporarily impaired after a dose of alcohol of even less than 40 cubic centimetres, *e.g.*, 30 cubic centimetres; especially in the diminished speed and nicety of the required act's performance. It seems therefore permissible to suppose that the greater the precisional delicacy and alertness demanded in a muscular act and the greater its degree of difficulty, *e.g.*, by reason of novelty to the performer, the more liable will that act be to show impairment under the influence of alcohol, and, within limits, the smaller will be the dose of alcohol which may impair the act. Reliable evidence that alcohol improves, in normal circumstances, the efficient performance of any muscular act, unskilled or skilled, seems at present to be altogether lacking.

Similarly the evidence points to the depression by alcohol, in any doses in which it effects them at all, of mental processes, if they involve in any degree the higher mental faculties. On the other hand there is evidence that the rapidity with which a simple memory, such as that of a word once seen, is recalled to consciousness may be increased by alcohol in moderate doses.

CHAPTER V.

Action of Alcohol on the Digestion.

Factors in digestion which may be influenced by alcohol.

The process of digestion is very complex and it is convenient to distinguish the following factors each of which might be modified by alcohol.

(1) The secretion, or outpouring, of the digestive juices, saliva, gastric juice, pancreatic juice and bile, which may be altered either directly, by some action upon the glands which form the juices, or indirectly, through nerves which convey impulses leading to alterations of quality or quantity in the juices poured out.

(2) The churning movements of the digestive organs, particularly the stomach, movements which normally aid digestion, but, when abnormal in kind or degree, hinder it and often cause pain.

(3) The actual digestion or chemical transformation of such food-stuffs as undergo it and their subsequent absorption after they have been more or less profoundly changed by the action of the digestive juices.

Effect of alcohol on secretion of digestive juices.

Beginning with (1) we may first inquire in general terms whether alcohol does, or does not, cause a flow of digestive juices, and if so, how. So far as the *saliva* is concerned, there is no doubt that alcohol taken into the mouth does, like any other sapid fluid, or indeed, like the act of chewing inert substances such as india-rubber, cause a flow of saliva. This action is not of much importance. So far as the *gastric juice* is concerned, the question is more important and the answer less simple. Thus, alcohol might cause a flow indirectly, by acting upon nerves of taste or smell; any agreeable taste in the mouth is well known to do this;

but we cannot say that this is peculiar to alcohol, and the only direct observation (upon a woman who had an artificial opening in her gullet and another in her stomach) did not afford any decisive information.

When alcohol reaches the stomach, it certainly arouses a considerable secretion of a juice, partly, perhaps, by directly irritating the wall of the stomach but largely through a specific action on the cells which manufacture the digestive juices. This has been proved by many experiments on animals and also by observations upon men who, in consequence of disease or injury, had had artificial openings made into their stomachs, through which alcohol could be introduced, often without the patients knowing what had been given. In animals, a part of the stomach separated from the main stomach secreted actively when alcohol was given by the mouth.

The gastric juice which is secreted owing to the action of alcohol is not, however, of a normal kind. It contains the usual amount of hydrochloric acid but very little pepsin —the ferment which is concerned in the digestion of albuminous substances by the stomach. In fact, all the pepsin which the juice contains has been merely washed out of the cells ; no fresh supply is formed in response to the action of alcohol. It accordingly follows that this increased amount of gastric juice is of little or no value in the process of digestion, although there is no reason to suppose that it is in any way injurious. So far as the amount of secretion is concerned, the increase, in dogs, is greatest when small doses of alcohol, producing in the stomach a concentration not higher than 10 per cent., are given. As the amount and its concentration increase, the rate of secretion falls off and there is a tendency to form much slimy substance (mucus). The greater the amount and the concentration, the greater the formation of mucus. When the alcohol was repeatedly given, even in dilute form, the mucus secretion became more marked and the increase of total juice smaller

It is said that the *pancreatic secretion* is also increased by alcohol, given by the stomach or by injection through the anus into the large bowel. This, together with the alleged increase in the secretion of *bile*, may in part be due to some action on the stomach, for an increase of gastric secretion often leads to an increase in the activity of the pancreas.

Action of alcohol on movements of stomach.

Passing to (2), the churning movements of the stomach are a natural part of the digestive process—they aid digestion. They aid it, not only by promoting digestion in the stomach itself, but also by duly passing on partially digested food from the stomach into the intestine, for the com pletion of its digestion there. It is commonly stated that alcohol promotes the movements of the stomach, but the experimental methods by which it has been sought to establish this conclusion were not altogether satisfactory. Chittenden,* for instance, did not find that the stay of food in the stomach of a dog was materially altered by the presence of alcohol. Carlson,† who investigated the movements of the stomach in a man with an artificial opening (fistula) into that organ, found that diluted alcohol, brandy and various wines introduced directly through the fistula, arrested the rhythmical movements and the bracing of the muscular coats (tonus) which are associated with hunger, but saw no increase of movement. 50-100 cubic centimetres (2-4 ounces) of 10 per cent. alcohol were enough to do away with the hunger contractions for two hours, and 200 cubic centimetres (half a pint) of beer had this effect for from half an hour to an hour. So far indeed as the evidence goes, it would seem that there is no reason to believe that gastric movement is increased by alcohol while some

* Chittenden, in Physiological Aspects of Liquor Problem, Vol. I. p. 294 ; Boston, 1903.

† Carlson. American Journal of Physiology. Vol. 32, p. 252, 1913.

forms of contraction are arrested. This lessened movement of the stomach, a so-called *carminative* action, is produced by many other volatile substances, and may explain the relief from discomfort and colic-like pains which such substances, including alcohol, may afford.

Effect of alcohol on activity of digestive ferments.

Finally, under (3), we take first the chemical process of digestion. It has already been said that the gastric ferment pepsin is not increased in amount by alcohol, but its activity might be. This is a matter which has engaged the attention of many investigators and their general results are concordant. The possible action in this way can be measured by ascertaining the amount of change which gastric juice is able to effect in food with which it is mixed in test tubes containing different small amounts of alcohol. It has been shown that while 1-2 per cent. of pure alcohol has little effect upon the activity of the juice, in the presence of from 5-10 per cent., digestion is slightly retarded, while a concentration of more than 10 per cent. very definitely diminishes the rate of digestion.

If the gastric juice used contains but little ferment, the retardation induced by even 10 per cent. alcohol is considerable. (Such a concentration can rarely, if ever, be present in the stomach of a living man for more than a few seconds).

Ordinary forms of spirits act on gastric digestion merely in proportion to the amount of alcohol they contain, but wines, especially red wines and sherry, retard digestion much more than can be explained by the alcohol they contain, evidently owing to the activity of some other constituents. The same is true of the beers, although these in small quantities have no pronounced effect. The above general statement applies equally to the salivary ferment, viz., little or no action when the proportion is low, retardation when the alcohol is stronger than 10

per cent. Here, again, wines and beers have a retarding effect out of proportion to their content of alcohol, an additional, and more powerful, factor here being the acidity of some wines.

Although some authorities have believed that the action of alcohol upon pancreatic digestion was less unfavourable than upon gastric digestion, one even stating that the digestion of fats is accelerated by it, there is no doubt that some of the ferments themselves, when examined in test tubes, are more sensitive to the action of alcohol than are those of the stomach. The digestion of albuminous substances may be delayed by so little as 2-3 per cent. concentrations. Spirits are here more deleterious than can be explained by their alcohol, while the acid reactions of wines and beers are unfavourable to the digestion.

In practice it is probable that alcohol reaches the intestine in such comparatively small quantities and such dilute solution, while it is also so quickly absorbed there that its action on pancreatic digestion is of small importance. To sum up these results, we may say that moderate quantities of alcohol, particularly when mixed with other foods, have no serious effect, good or bad, upon the chemical processes of gastric or pancreatic digestion, and this is true both of persons who are moderate users of alcohol and of total abstainers.

Psychic effect of alcohol in relation to digestion.

It has been suggested that the action of alcohol upon the central nervous system, the brain and spinal cord, may help digestion by distracting the subject's attention from worries and promoting a more cheerful outlook upon life, because of the interaction of the nervous system with other organs of the body. Whether this is or is not the case cannot be determined by laboratory experiment. It is a matter of common knowledge that many people eat, they say, with more appetite, if alcohol is drunk

with or before the meal, but there is no reason to think that the actual transformation of food into substances fit to be absorbed is increased, although one may derive more pleasure from a meal at which alcohol is taken.

Alcohol and the absorption of food.

With respect to absorption itself, that is the passage of the digested food-stuffs into the blood, while there is no doubt that some drugs, for instance chloral and strychnine, are readily absorbed when given in alcohol, more so than when taken in water, and there is some reason to think that small quantities of alcohol in the intestine promote the absorption of food-stuffs, there is no reliable evidence leading to the conclusion that moderate doses have any serious effect, one way or the other, upon the process of absorption of food.

The possibility that alcohol may promote the absorption of harmful bodies which would not otherwise make their way into the blood, is considered elsewhere.*

Excessive doses of alcohol are liable to cause vomiting, partly through local irritant action in the stomach but mainly indirectly through disturbances in the nervous mechanisms.

The whole subject of this section can be epitomised in the following terms:—

Conclusions.

Moderate doses have never been shown to affect appreciably the digestive organs apart from their taste and their tendency to increase the secretion of fluid and mucus from the walls of the stomach.

On the other hand, there is a consensus of opinion that some of the alcoholic beverages may be more deleterious than others; wines which do not noticeably interfere with

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* See p. 104.

the digestion of one man may cause trouble to another.* The alcohol present in these wines cannot be regarded as responsible, for the effects are not observed when the same quantity and concentration of alcohol is taken in another form. The solid non-volatile bodies in the wines have usually been blamed for the dyspepsia sometimes associated with the use of them, and possibly with justice. But it is not possible to dismiss the volatile bouquet substances from consideration, as similar differences are observed in the use of different forms of spirits where the non-volatile substances are present in but very small quantities and appear to be harmless. In these spirits, the higher alcohols (fusel oil) and the ethers are popularly credited with the action on the stomach, and there is some ground for believing them more disturbing to the digestion than pure alcohol. The changes induced by these bodies are, however, quite unknown, and may be different in character from those due to alcohol itself.

* Roberts. Collected Contributions on Digestion and Diet, 1891. Chittenden, in Physiological Aspects of Liquor Problem, Vol. I, 1903.

CHAPTER VI.

Action of Alcohol on the Respiration and on the Circulation of the Blood.

This chapter is concerned with some of the minor effects which follow the use of alcohol in moderate doses ; effects so small that they are easily overlooked altogether, and have no real importance in the ordinary use of alcohol by normal persons.

In the literature devoted to the action of alcohol these effects have received an amount of attention which seems out of proportion to their real significance.* There are two reasons for the importance which has been attributed to them.

In the first place it must be realised that a large part of the reputation which alcohol has enjoyed as a medicine is attributable to the belief that it stimulates a feeble heart or failing respiration. With medical men, until comparatively recent years, alcohol was the favourite "respiratory and cardiac stimulant," and, indeed, practically the only one available. It is still the most popular domestic remedy for the temporary failure of the heart, and secondarily of the respiration, which is known as "fainting." It is clearly of importance, therefore, to know whether alcohol really possesses the stimulating action on these vital functions with which it has been generally credited.

A second reason for the amount of investigation which has been devoted to these effects is that the discussion of their nature formed part of a wider controversy, concerning the action of alcohol on the body generally, and especially on the brain and nervous system. In the chapter dealing

* For a general review of the literature, except for recent years, see Abel, in "Physiological Aspects of the Liquor Problem," Vol. II, Boston, 1903.

with the mental action, we have seen that one school of opinion has maintained that moderate doses of alcohol have a truly stimulant action, while another school has regarded the appearance of increased mental activity as misleading, and has supported the view that alcohol, even in the smallest dose having any perceptible effect, is always depressant or paralysing in its action. The effects on the respiration and the pulse are such as can easily be measured and recorded, and the partisans of the one theory were accordingly eager to demonstrate that alcohol had a genuine stimulant action in these cases, however small it might be; while their opponents showed a corresponding anxiety to prove that any appearance of such a stimulant action could be explained in other ways.

Sub-Chapter I.

The Action of Alcohol on Respiration.

Normal working of respiratory mechanism.

The movements of respiration, by which air is rhythmically drawn into and expelled from the lungs, show wide variations both of depth and rhythm, even under normal conditions of active life. These movements are initiated by the activity of a nervous centre, called the "respiratory centre," which is situated in the hindmost part of the brain, just above the level where it becomes continuous with the spinal cord. The activity of the centre is normally called forth by the presence of carbon dioxide in the blood carried to it by the circulation. If the blood is deprived of carbon dioxide completely, the breathing stops altogether If the quantity of carbon dioxide in the blood becomes abnormally great, the respiration becomes rapid and laboured; as when we find ourselves "out of breath" after running up a flight of stairs. The action of the centre is also modified by the activity of other parts of the brain and

nervous system. The respiration is to a large extent controllable by the will, and is affected by every emotion; we "gasp with astonishment," "hold the breath with anxiety," or "pant with eagerness." It is also subject to "reflex" effects from the stimulation of sensory nerves; a sudden pain, a dash of cold water on the skin, makes us gasp or pant for breath.

Indirect effects of alcohol on respiratory activity.

Since the rhythm of breathing is normally subject to such wide variations, it is clear that a small effect of a drug will be difficult to detect with certainty, unless special precautions are taken. Under ordinary conditions a dose of alcohol will produce, in many persons, a condition of excitement, talkativeness, and restless muscular activity. The fact that this is accompanied by quicker and deeper breathing cannot be taken to represent an action of alcohol on respiration; for a similar access of respiratory activity can be seen in persons of excitable temperament if, without having taken alcohol, they become engaged in animated discussion and gesticulate freely.

Earlier observations: difficulties in their interpretation.

Many competent observers formerly stated, however, that the taking of a moderate dose of alcohol, by a subject kept in repose and carefully protected from disturbing influences, was followed by a small but definite increase of respiratory activity. All forms of increase in activity were recorded: a quicker rate, with deeper, unaltered, or shallower individual respirations, or even a deepening of each breath without alteration of the rate. The nett result was, however, in general an increase in the volume of air breathed in a given time. One observer stated that the effect was more pronounced with a wine of fine bouquet than with pure alcohol, and noted its special prominence in subjects suffering from fatigue. A long

and vigorous discussion arose as to the nature of this effect. It would be unprofitable to follow this into all its detail, and it will suffice to indicate the main lines of the argument. Those who believed that alcohol never stimulates the brain, and who were therefore unwilling to admit that it would stimulate the respiratory centre, attributed the effect to an irritant action on the mucous membrane of the stomach. The similar effects seen in experiments on animals, when the alcohol was inhaled as vapour, or injected under the skin, were similarly attributed to irritation of the lining of the wind-pipe and the lungs, or the nerves in the subcutaneous tissue. Other irritant substances, such as mustard, were said to cause a similar increase of respiratory movement, when they were introduced into the stomach.*

On the other hand, the adherents of the "stimulant" theory of the action of alcohol claimed the effect on respiration as supporting their view. They pointed out that the effect was apparently not diminished by diluting the alcohol freely with water before it was swallowed; whereas the irritant action of strong spirit would be greatly reduced by such dilution.† They laid much stress also on the fact that the injection of suitably diluted alcohol directly into the vein of an animal was followed by an increase of respiratory activity; and under such conditions, there was no possibility of local irritative action affecting the respiratory centre indirectly.‡

Experiments to test the effect of alcohol on the excitability of the respiratory centre.

In the light of more modern information concerning the normal activity of the respiratory centre and the

* Jaquet—Archives Internationales de Pharmacodynamie, Vol. 2, p. 107. 1896.

† Wilmanns—Pflüger's Archiv. für die gesammte Physiologie, Vol. 66, p. 167. 1897.

‡ Binz—Centralblatt für innere Medizin, p. 1. 1891.

manner of its control, much of this discussion seems irrelevant. We have seen that the respiratory centre does not work automatically, but only in response to the stimulating action of carbon dioxide in the blood. When it is suggested, therefore, that a drug like alcohol has a "stimulant" action on the respiratory centre, this can only mean that it makes the centre more readily responsive to carbon dioxide. The excitability of the centre can be tested, by measuring the effect produced on the breathing, when a definite proportion of carbon dioxide is added to the air which is breathed. Such a measurement, before and after a dose of alcohol, was indeed made many years ago.*

Two subjects were chosen for the experiments, one accustomed to taking alcohol, the other not. Each was given, on separate occasions, a dose of 35 cubic centimetres and another of 60 cubic centimetres of alcohol. The quantities of whisky at proof containing these amounts of alcohol would be $2\frac{1}{2}$ ounces and rather less than $4\frac{1}{3}$ ounces respectively. Only in one case was an increase in the excitability of the respiratory centre detected, namely, when the larger dose was given to the person who was not used to taking alcohol.

Proportion of carbon dioxide in "alveolar air" as a measure of the excitability of the respiratory centre.

Another method of measuring the excitability of the respiratory centre has been used in more recent experiments. The activity of the centre so adjusts itself to the need of the body to get rid of carbon dioxide, that the proportion of carbon dioxide in the blood filling the arteries is kept practically constant. The gases held by this blood are in equilibrium with the air in the deepest

* Loewy—Pflüger's Archiv. für die gesammte Physiologie, Vol. 47, p. 601. 1890.

recesses of the lungs—the so-called " alveolar air." Samples of this air can easily be obtained and analysed, and it has been found that the proportion of carbon dioxide in it remains very constant in the same individual under similar conditions. When the. rate at which carbon dioxide is being formed in the body increases, the respiratory centre is stirred to greater activity, and the more active breathing quickly readjusts the proportion of carbon dioxide in the alveolar air to its normal level.

Now it will be clear that, if the normally constant proportion of carbon dioxide undergoes a change and reaches a new level, this must indicate a change in the excitability of the respiratory centre. If *more* carbon dioxide accumulates in the air in the lungs, we know that the excitability of the centre has become *less ;* for otherwise the tendency to such accumulation would have excited the centre to greater activity, and the more vigorous breathing would have swept carbon dioxide out of the lungs more rapidly, so as to maintain the normal proportion. If, on the contrary, the proportion of carbon dioxide in the alveolar air becomes *less,* we know that this indicates an *increase* in the excitability of the centre ; for otherwise the tendency to diminution of the amount of carbon dioxide would have resulted in smaller activity of the centre, and the slower and shallower breathing would have allowed the normal proportion of carbon dioxide to remain. More active breathing may, therefore, be brought about either by an increase in the excitability of the respiratory centre to the normal proportion of carbon dioxide, or by a more rapid production of carbon dioxide by the body. In the former case, a decrease in the proportion of carbon dioxide in the alveolar air would be detected, in the latter it would not change perceptibly. The two influences may work in opposition —*e.g.,* an increase in the excitability of the centre may be accompanied by diminished production of carbon

dioxide ; and in such a case there may be no change, or even a decrease of respiratory activity, although the excitability of the centre has risen.

Experiments to determine the effect of alcohol on the proportion of carbon dioxide in the " alveolar air."

It will be clear that the interpretation of an apparent effect of alcohol on breathing is a much more complicated matter than the earlier investigators supposed. More recently the changes in all the different factors have been carefully investigated in a series of men.* Seven subjects were chosen for the experiments, whose experience of alcohol included all variations from habitual abstinence to daily use. In each test two doses were used, 30 cubic centimetres and 45 cubic centimetres of pure alcohol, suitably diluted with a flavouring mixture ; the equivalents in alcohol of whisky at proof would be rather more than 2 ounces and 3 ounces respectively. The doses were large enough to produce distinct physiological effects—feelings of comfortable warmth and drowsiness, and in some cases talkativeness and mental excitement ; on the other hand, they were not enough to cause definite inebriation. The patients were kept carefully at rest, and under constant observation, and each alcohol experiment was controlled by one in which the subject took the same flavouring mixture without the alcohol.

In a certain proportion of the experiments there was an indication of a slight increase in the excitability of the respiratory centre, the proportion of carbon dioxide in the alveolar air undergoing a small reduction after alcohol had been taken. This effect, however, was counterbalanced by a diminished production of carbon dioxide

* Higgins—Journal of Pharmacology and Experimental Therapeutics, Vol. 9, p. 441. 1917.

by the body. The nett result on the breathing was that the volume of air breathed per minute was either unchanged or slightly diminished.

Another attempt to settle this question has been made by Hooker*, who, by an ingenious method of artificial perfusion, has tested the direct action of alcohol on the respiratory centre, isolated from the general circulation. His results show that, on the centre thus isolated from other influences, low concentrations of alcohol have a recognizable stimulant action. It is clear, however, that the only fact which Hooker's experiments demonstrate is the existence of this stimulant effect on the respiratory centre, when all other influences are kept constant. The point has theoretical and scientific interest, but so far as the practical issue is concerned, Higgins' observations, while they also detect this effect on the excitability of a centre, show that in the intact individual it is more than counterbalanced by the concurrent fall in production of the normal stimulant, carbon dioxide.

Conclusions regarding the action of alcohol on respiration.

There need be no hesitation in accepting these experiments, made by the best methods yet available, as giving a true account of the action or want of action of alcohol itself on the respiration. The fact that a definite, though small, increase in the volume of air breathed was so consistently observed by the earlier workers to follow the taking of alcohol, may be explained in one of two ways: either (1) their precautions against an increase of muscular activity following the taking of alcohol were imperfect, so that the effect they observed was in part the indirect result of more rapid formation of carbon dioxide; or (2) the wines, brandy, &c., used in some of the earlier experiments contained, among their ethereal bouquet-

* J. Pharmacol and Exper. Therap. Vol. 10, p. 121. 1917.

substances, some which had more action on the respiratory centre than alcohol. Only further experiment, by modern methods, could decide between these possibilities. For our present purpose it is sufficient to have reached the conclusion that alcohol, in moderate doses, has no effect on the respiration of practical importance, either for its use by normal persons, or for its medicinal use. The only important effect of alcohol on respiration is the paralysis of the respiratory centre by large doses, which, as another chapter shows,* is the cause of death in poisoning.

Sub-Chapter II.

Action of Alcohol on the Circulation of the Blood.

In what ways a drug may influence the Circulation.

A drug can influence the circulation of the blood by causing either a change in the rate or strength of the heart's beating, or a change in the state of contraction of the blood-vessels, especially of the smaller arteries. The heart is a muscular pump, which at each beat drives a spurt of blood into the great arteries, causing a wave of pressure, the pulse-wave, to travel down them. Where the large arteries divide into small ones, and these again open into the net-work of capillary blood-vessels, the flow of blood encounters a pronounced resistance. As a result of this resistance, and of the elasticity of the larger arteries, a head of pressure is built up in these, by which the blood is driven on through the capillaries into the veins in a steady stream. The maintenance of this "arterial blood-pressure," which is one of the essential factors of an efficient circulation, depends on the rate and volume of the heart-beat, and on the state of contraction of the small arteries. The arterial pressure rises when the heart-beats follow one another more rapidly, or when the volume of blood expelled at each beat increases; and it rises also when the walls of

* Chapter VIII, p. 95.

the small arteries contract, and increase the resistance to the flow of blood out of the arteries. If the heart-beat becomes slower or weaker, or if a general relaxation of the small arteries occurs, the arterial blood-pressure falls. But the arteries of the whole body need not, and do not usually contract or relax together. The arteries in the skin, for example, may contract, while those of internal organs relax ; and the result may be that, while the pressure in the large arteries is unchanged, a larger proportion of the blood goes to the internal organs, and less to the skin than before.

In discussing the effect of alcohol on the circulation of the blood, the main points on which information is required are, therefore, its effect on the rate and strength of the heart-beat or the pulse, and its effect on the state of contraction of the smaller arteries ; and we further have to inquire whether, as the result of the effects on the heart and arteries, any change occurs in the pressure of the blood in the larger arteries.

Effect of alcohol on the superficial blood-vessels.

There are only two features of the action of moderate doses of alcohol on the circulation concerning which there is anything like a general agreement. All who have studied the matter are agreed as to the general relaxation of the small arteries carrying blood to the skin. This causes a slight general flushing of the surface and accounts for the comfortable feeling of bodily warmth which the taking of alcohol produces. It is more important for its effect on the body temperature, which is dealt with in the following chapter, than for its effect on the general circulation of the blood. But it will be clear, from what has been said above, that such a dilatation of the skin vessels will be attended by some fall of the arterial blood-pressure, unless it is compensated either by a constriction of arteries carrying blood to internal organs, or by an increase in the activity of the heart.

Effect of alcohol on the pulse-rate.

The majority of observers are further agreed in stating that the swallowing of a moderate dose of alcohol is followed by an increase in the rapidity of the heart-beat, which lasts for about half an hour. There are some who have failed to detect this action, and others even who observed that the pulse became slower after alcohol was taken. The rate of the pulse is not a matter concerning which there can be a difference of opinion, and it can only be concluded that different subjects react differently to alcohol in this respect, while dose and dilution have probably some influence on the effect. There seems to be no doubt that a slight quickening of the pulse commonly occurs. In a recent series of experiments on the effect of alcohol on respiration, described in the foregoing section, records of the pulse-rate were taken. These showed a small acceleration, following the taking of alcohol, in about half the experiments. In the others no change was detected.*

Quickening of the pulse under alcohol is probably brought about indirectly.

There is very good reason, however, for believing that this effect, weak and inconstant as it is, is not due to a direct action of alchool on the heart. It has been seen to occur when alcohol of sufficient concentration (50 per cent.) was simply taken into the mouth and rejected without being swallowed. In this case, the quickening of the pulse only lasted for a few minutes, whereas, if the dose was swallowed, the quickening lasted for half an hour or so.† It seems reasonable to attribute at least a part of the result to the continuance in the stomach of the irritating action of alcohol on mucous membranes, which must be the immediate cause of the effect seen when alcohol is held in the mouth.

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* Higgins—loc. cit.

† Dixon—Journal of Physiology, Vol. 35, p. 346. 1907.

The heart-beat, though automatic, is under the constant controlling influence of the nervous system. Under normal conditions, the heart is held in check by impulses from an "inhibitory centre," so that the rate is less than that at which the heart would beat if freed from such control. This restraint can be weakened by various causes. The quickening of the heart in response to the irritation of mucous membranes by alcohol is probably an example of a reflex weakening of this control. A quickening of the heart, largely due to a similar action, regularly accompanies muscular activity; and it is not unlikely that the tendency to restless movement, which follows the taking of alcohol, also plays its part as an indirect cause of the quickened pulse. That the effect is, in the main, an indirect one has been shown by experiments, conducted by a number of observers, on the action of alcohol on the heart isolated from the body.

Experiment to test the action of alcohol on the isolated heart.

The heart of a recently killed animal, if blood or a suitable nutritive fluid is made to flow through its blood-vessels, can be kept beating for hours or days outside the body. Under such conditions its action is uncomplicated by changes in the rest of the circulatory system, and is free from all nervous control. Alcohol in accurately measured proportion can be added to the fluid perfusing the heart, and the direct and uncomplicated effect of such additions on the beat of the heart can thus be studied.

Most of those who have made such experiments have failed to detect any quickening or strengthening of the heart-beat under the influence of alcohol of any concentration.* Such observers found that, in concentrations up to about 0.1 per cent., alcohol was without effect.

* *See* Backman—Skandinavisches Archiv für Physiologie, Vol. 18 (1906), p. 323, who gives full references to earlier work on these lines.

Others have observed some strengthening of the beat as the result of such low concentrations of alcohol.* This, however, appears to have been due to the fact that the heart, during the long perfusion, had used up much of its reserve supply of food-material, needed for producing the energy of its beat, and that, under such conditions, it was able to use alcohol as a fuel, just as it can use glucose (grape-sugar) added to the perfusion fluid. So that there was no evidence that alcohol, in these concentrations, had a specific stimulating action on the activity of the heart ; on the other hand, it was harmless.

Direct effect on the heart only observed with large doses, and then of depressant character.

All are agreed that in greater concentrations alcohol is directly harmful to the heart. The investigators differ as to the concentrations at which the harmful effect begins to be manifest. Those who used a purely saline fluid for perfusion through the vessels of the heart observed a depressant action as soon as the proportion of alcohol rose above 0.1 per cent. On the other hand, in experiments in which blood was perfused, even 0·5 per cent. of alcohol was found by one observer to have no definitely harmful action.† It will be seen later (Chapter VIII) that when, in man, the concentration of alcohol in the circulating blood rises above 0·1 per cent., the condition of the subject becomes one of definite inebriation, while at a concentration of 0·5 per cent., we are approaching the fatal limit. There seems no good reason, therefore, for ascribing to direct stimulation of the heart any favourable effect which a small dose of alcohol may appear to produce, or to direct depression of the heart a large share in the danger to life produced by poisonous doses. The effect in either case,

* Dixon—loc. cit.

† Loeb—Archiv für experimentelle Pathologie und Pharmakologie, Vol. 52, p. 451. 1906.

whether of quickening or depression, must be mainly the indirect result of the other actions of alcohol.

Effect of alcohol on arterial blood-pressure.

The effects of alcohol on the arterial blood-pressure are similarly small and indefinite. Some observers have described a relatively small rise of the arterial pressure, as the result of injecting small doses of alcohol directly into the circulation.* Others have failed to detect any definite effect, or have observed a small decline of arterial pressure; one found that the pressure fell if alcohol was injected into a vein or under the skin, but rose to a small extent, for a few minutes, if the same dose of alcohol was swallowed.†

Conclusions.

The action of alcohol on the heart and circulation has theoretical interest for the pharmacologist, and has accordingly been the subject of much investigation and discussion. But no scientific ground has been discovered for any claim made on behalf of alcohol to practical value as a *direct* stimulant of the heart in cases of threatened failure of the beat. When it appears to promote recovery from fainting, it probably acts simply by virtue of its irritant action on the mucous membrane of the mouth and throat. The fact that the beneficial effect appears almost immediately, and long before any significant amount of alcohol can have been absorbed and carried to the heart, is evidence for this local and indirect nature of the action. Its use in these circumstances is, therefore, comparable

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* Dixon—Loc. cit.
Kochmann—Archives Internat. de Pharmacodyn. Vol. 13, p. 329. 1904.
Bachem—Archives Internat. de Pharmacodyn. Vol. 14, p. 437. 1905.

† Brooks—Journal of the American Medical Association. Vol. 30, p. 373. 1910.

with that of smelling salts, or the irritating fumes of burnt feathers, traditionally employed for the same purpose. When, in conditions of more protracted weakness of the heart, the administration of alcohol has a beneficial effect, this must be attributed mainly to its mildly narcotic and sedative action, relieving the centres which modify the action of the heart, from the disturbing influence of pain and anxiety. The promotion of a patient's comfort, the relief of mental strain, may be an essential element in the treatment of disease, and an important factor in recovery. It does not, however, justify the description of alcohol as a "stimulant" of the heart. In this case, as in others, the popular idea that it is a "stimulant" proves on examination to be scientifically untenable.

CHAPTER VII.

The Influence of Alcohol on the Body Temperature.

Distinction between surface temperature and deep temperature.

In speaking of body temperature we must carefully distinguish between the surface temperature, *i.e.*, the temperature of the surface of the skin, and the deep temperature, which is that of the underlying parts and the internal organs.

The surface temperature is in general lower than the deep temperature, but the most important difference between the two is that, whereas the surface temperature varies widely, not only at different times but on different areas of the skin at the same time, the deep temperature is, in health, remarkably constant. If one hand is plunged into hot water (at 45 degrees Centigrade, *i.e.*, 113 degrees Fahrenheit, for example) and the other into melting snow, the surface temperature of the former rises higher than the deep temperature, while that of the latter falls far below it. If the temperature on the surface of the body be taken immediately on rising from bed on a winter's morning, and again immediately after a cold bath, it will be found to have fallen through a long range. Through all these changes, however, the deep temperature will have remained practically unaltered, as may be verified by taking the temperature under the tongue, with the lips closed, before and after the cold bath.

This maintenance of the deep temperature at a practically constant level, with but small fluctuations from its normal average of 37 degrees Centigrade* (or 98.6 degrees

* Normally the temperature curve exhibits a regular diurnal cycle, reaching a maximum between 4 p.m. and 8 p.m. and a minimum between 2 a.m. and 6 a.m. The extreme range is between 1 and 2 degrees Fahrenheit, and the cycle is related to variations in the activity of metabolism.

Fahrenheit) is an essential condition of health; for it is only at this temperature that the chemical and physical changes of the living tissues proceed at their normal rate. This constancy of the deep temperature gives to the clinical thermometer its value as an instrument for detecting the onset of illness, and for measuring its progress.

How the deep temperature is maintained at its normal level in health.

We have seen that the chemical changes of the body, viewed as a whole, are in effect a combustion, and are accompanied by the evolution of heat. This constant production of heat renders the body warmer than the air and most of its surroundings. Heat is, therefore, always being generated in the body, and always being lost at its surface to the air. The maintenance of the deep temperature at its normal level involves a continual adjustment of these two processes, so that the amount of heat lost at the surface just balances the amount that is evolved within. The rate at which heat is produced in the body is always varying with changes in the activity of the muscles and of the glandular organs. The rate at which heat is lost from the body is likewise subject to continual variations with changes in the temperature and moisture of the air, in the degree to which the skin is exposed to it, and in the rate at which winds and currents keep the cool air moving over the surface of the body.

The heat-regulating centre.

The adjustment of processes by which heat is produced and lost by the body, so that an accurate balance is maintained, is under the control of a nervous centre in the brain, the unconscious action of which suffices for moderate changes of the external or internal conditions. We may confine our attention to the manner in which the body

protects itself against a *fall* of the deep temperature, since this is of the greatest importance in connection with the action of alcohol.

Automatic adjustment of body temperature in exposure to cold.

When the body, by exposure to cold, is threatened with a loss of heat at a rate exceeding that of its production, the first means of readjustment is a change in the distribution of the circulating blood as between the skin, where heat is lost, and the internal organs, where it is evolved. The nerves of the skin, excited by the surface cooling, call into action the nerve centre regulating the body temperature; this, through the nerve-centre which controls the contraction of the small arteries, causes a narrowing of the channels through which blood is conveyed to the skin. Less of the blood streams through the cold skin, and more through the heat-producing organs in the interior. The result is a further fall of temperature of the skin; but the all-important deep temperature is maintained. If the exposure to cold is more severe or prolonged, the narrowing of the blood vessels in the skin is inadequate to protect the body against excessive loss of heat, and the deep temperature, including that of the blood, begins to fall. As the blood cools it acts on the heat regulating centre, through which the heat-producing organs, such as the muscles, are stimulated to activity, so that a more rapid evolution of heat takes place. We become conscious of the almost uncontrollable rhythmic contraction of the muscles and call it "shivering."

How conscious effort instinctively assists automatic mechanism.

So far we have dealt with the automatic, involuntary mechanism for maintaining the deep temperature of the body at a constant level. In the normally alert and sensitive person this automatic regulation is assisted by

conscious effort. Before the stage of shivering is reached we become conscious of a definite, unpleasant sensation, which we describe as "feeling cold." This is due to the fall in the temperature of the skin, accelerated, as we have seen, by the diversion of the blood to the interior of the body. Of a fall in the deep temperature we are not directly conscious, and are made aware of it only through the reaction of shivering. The feeling of discomfort and misery thus engendered is a natural warning of impending injury by cold, a signal that the deep temperature is beginning to fall, and that the balance between production and loss of heat can no longer be upheld by the unconscious reflex mechanism. The desire to reinforce the automatic adjustment by conscious effort becomes urgent. We find ourselves impelled to accelerate the production of heat by vigorous muscular activity and to restrict still further the rate of its loss from the surface by putting on more clothes. If the excessive surface cooling, which is the cause of discomfort, is confined to a small part, such as a hand, we may endeavour to alleviate it by beating and chafing the part affected, and thus restoring in it a freer circulation of blood.

Alcohol causes loss of heat through flushing of surface.

Turning now to the action of alcohol, it will be remembered that, in the previous chapter (p. 81), mention was made of a general flushing of the skin surface, a widening of the small arteries carrying blood to the skin, as one of its effects on the circulation of the blood. We saw, indeed, that this was the only one of its effects on the circulation concerning which there was no doubt or difference of opinion.

In considering the bearing of this effect on the regulation of the body temperature, we must note, in the first place, that such flushing of the skin has, as a necessary result, an accelerated loss of heat from the surface of the body. The question arises whether this is balanced by an increase in the production of heat by the internal organs.

There is no evidence to indicate that alcohol directly affects the rate at which heat is formed in the body. Indirectly, indeed, it may increase the rate of heat production, by weakening the control of the brain, and thereby favouring a restless muscular activity. In a resting subject it does not increase the production of heat, and the result of its effect on the circulation through the skin is a fall of the deep temperature.

Alcohol blunts the warning sensation of cold.

So far as the unconscious reaction to external cold is concerned, therefore, the effect of alcohol is to weaken the action of the heat-regulating centre, so that the protective constriction of the vessels carrying blood to the skin is relaxed. What of the conscious, instinctive reaction? The flushing of the skin relieves the unpleasant sensation of "feeling cold," and replaces it by a comfortable glow of warmth. We have seen that under conditions of exposure to cold the unpleasant sensation is a valuable warning, which assists the maintenance of the deep temperature by creating an impulse towards muscular exertion, so that the production of heat is accelerated. This warning sensation alcohol blunts or annuls, and thereby tends to preclude the instinctive protective action which the warning should call forth. It impairs or annuls, therefore, the conscious, instinctive reaction, as well as the automatic, reflex mechanism of adjustment. From the point of view of maintaining the deep temperature, the influence of alcohol is evidently wholly bad. Its popular reputation as a means of "warding-off cold" is due to the relief which it affords from the warning discomfort.

Practical conclusions regarding use of alcohol by persons exposed to cold.

If the practical question is asked, therefore, whether a person who feels cold can take alcohol with advantage, the

answer must depend on a balance between discomfort and danger. Whereas it may well be considered legitimate to incur a trivial danger in order to avoid a considerable discomfort, even serious discomfort is not worthy of consideration if the alternative is danger to life itself.

It may be safely stated that, under the conditions of ordinary life indoors, or in the open when the temperature of the air is mild, the effect of a moderate dose of alcohol on the body temperature has no importance. In circumstances of brief exposure to cold, with the body as a whole well clad, the discomfort due to a chilling of the face and extremities may be mitigated by the use of alcohol without likelihood of producing a dangerous fall of internal temperature. The mental depression which accompanies the feeling of being "miserably cold," the discomfort of numbed hands, can be alleviated by a small dose of alcohol; and the relief, though short-lived, reacts favourably for the time being on the complexion of the mind. The cheerfulness and sense of energy, which thus replace dejection and apathy, will not improbably awaken a desire for muscular activity; so that the temporary and, in itself, illusory relief, provided by alcohol, may pave the way to the more genuine, natural and permanent remedy.

Such uses of alcohol, for the relief of the feeling of cold, are suited only to a very brief emergency, created by exposure to a degree of cold which is merely unpleasant. The taking of alcohol during, or as a preliminary to, prolonged or severe exposure to cold, is on every ground to be condemned. Any sensation of warmth which it produces is, under such conditions, an illusion fraught with danger; its effect is to render the subject indifferent to a peril which is in fact seriously increased by its use.

When, on the other hand, the exposure to cold is at an end, and the victim has been placed under conditions promoting warmth, the use of alcohol may have real value. If, for example, the surface of the body has

become chilled and the deep temperature has been lowered by prolonged immersion in cold water, when once the patient has been wrapped in hot blankets and surrounded with hot bottles the administration of alcohol can assist the restorative measures by promoting the return of blood to the superficial tissues, to which the external heat is applied.

CHAPTER VIII.

Poison Action of Alcohol.

Drug action and poison action differ only in degree.

In the case of alcohol, as in the case of other drugs, it is impossible to draw any hard-and-fast line between drug action and poison action. Drug action, when, with increase of dose, it becomes excessive, passes into poison action; but there is no absolute criterion of excess, and an action which under one set of circumstances and from one point of view may be regarded as excessive and harmful, may under other circumstances come within the denomination of a drug action. For instance, a person who drinks such a quantity of ether that he becomes unconscious would certainly be considered to be suffering from poisoning, and yet we do not ordinarily speak or think of poisoning in the case of a patient under an anæsthetic, though his condition may represent a more intense and dangerous action of the same drug. In reference to alcohol, then, it will be sufficient if, without trying to be too precise, we take it that a drinker really begins to suffer from acute poisoning as soon as he shows such immediate effects of the drug as interfere with his normal capacity for taking care of himself.

The symptoms of ordinary drunkenness have been fully described in Chapter III, where it was pointed out that they result from a progressive impairment of the functional activity of the nervous centres in the order from the highest to the lowest, that is to say, beginning with the centres of the brain that have to do with complex mental processes, such as those involved in critical judgment and self-control, and subsequently, with deepening intoxication, affecting lower levels until finally a state of stupor is reached.

In this final stage of intoxication, when the drinker, in common parlance, is " dead drunk " or " paralytic drunk," the nervous centres which control such vital activities as the movements of the respiratory muscles are more or less interfered with, as shown, for instance, by the snoring or " stertorous " breathing which accompanies the unconsciousness of drunkenness. Ordinarily, this condition passes gradually into a state of deep sleep, after which the patient returns to the normal. In some cases, however, when the quantity of alcohol taken has been very large, these vital centres are so gravely affected that the drunkard may die from failure of respiration.

Symptoms due altogether to action on central nervous system.

All the symptoms of drunkenness, then, are due essentially to the action of alcohol on the brain and the rest of the nervous system. Even when it kills by acute poisoning it kills through its action on that system, and not by directly injuring any other bodily organ. This, indeed, we are already prepared to find, for, as we saw when dealing with the action of alcohol on the other functions of the body, it is only when very large doses of the drug are taken that it can produce an immediate effect of any significance on these functions: thus, for instance, to depress the action of the heart to an appreciable degree by directly influencing that organ, we saw (Chapter VI, p. 84) that alcohol must be present in the blood in a proportion of about 0.5 per cent.—a proportion which would imply an original dose, for a man of 10 stone weight, of nearly 12 ounces of absolute alcohol, or well over a pint of whisky at proof strength. With such a dose, of course, in an ordinary individual the direct effect on other organs would be negligible in presence of the symptoms of profound and dangerous intoxication of the central nervous system.

Relation of symptoms to amount of alcohol in blood.

The next point which we have to consider is how drunkenness is related to the amount of alcohol taken, and to the particular sort or sorts of alcoholic beverage drunk. We shall deal first with the question of dose. Alcohol reaches the central nervous system by passing from the blood into the fluid—the cerebro-spinal fluid, to give it its technical name—which bathes the brain and the spinal cord as they lie within their lining membranes in the skull and the spine; and the amount of the drug which enters this cerebro-spinal fluid is strictly proportional to the amount contained in the blood. From experiments on animals and from observations on man, it has been found that the onset and the intensity of the symptoms of intoxication are roughly dependent on the quantity of alcohol present in the circulation. Thus in experiments on dogs and horses it was ascertained that the animals began to be slightly affected when the proportion of alcohol in the blood reached the level of 0.12 per cent., that with higher proportions the symptoms became more marked, and that profound stupor, frequently ending in death, ensued when the alcohol content rose to 0.72 per cent.* Similarly in cases of drunkenness in man, the blood has been found to contain, in one observation 0.153 per cent. of alcohol, and in another instance, when the intoxication was more pronounced, 0.227 per cent.†; and it is generally accepted that with a blood content of over 0.6 per cent., there is a considerable likelihood of death.‡

These figures, however, do not convey much meaning until we have translated them into terms of doses as drunk.

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* Quoted in Kobert, Lehrbuch der Intoxikationen, Vol. 2, p. 986. Stuttgart, 1906.

† Schweisheimer, Deutsches Archiv f. klin. Medizin, Vol. 109, p. 271. 1913.

‡ As qualifying this statement, see under "Tolerance," p. 99.

This we can easily do if we refer back to what was said in Chapter II concerning the absorption of alcohol into the blood and its subsequent fate in the body. It was explained in that chapter (p. 25) that alcohol passes rapidly from the stomach and bowel into the circulation, and that, owing to the slowness with which it is burned or excreted, the amount present in the blood soon reaches a maximum level, bearing a pretty constant relation to the dose originally drunk. So that, knowing the quantity of absolute alcohol taken and the body weight of the drinker, we can at once give an approximate estimate of the maximum proportion of the drug which will be found in the circulation; and conversely, we can say what amount of alcohol must be administered to give any particular percentage in the blood. Thus, taking the figures which we have quoted, the proportion of 0.15 per cent. which was found in the blood in the less pronounced case of intoxication, would correspond to an original dose of 1.5 cubic centimetres of absolute alcohol for each kilogramme of body weight, and this amount, expressed in English measure, would be roughly equivalent, in the case of a man weighing 10 stone, to a total dose of $3\frac{1}{2}$ ounces of absolute alcohol, that is to say, nearly a gill and a half of whisky at proof, or rather more than 4 pints of beer of average strength (*i.e.*, containing 4 per cent. absolute alcohol).

Lethal dose of alcohol.

Again, if we accept 0.6 per cent. as being approximately the alcohol content of the blood in dangerous poisoning, we shall put the fatal dose of the drug, for a man of the weight given above, at about 14 ounces of absolute alcohol, or nearly a pint and a half of proof spirit. The quantity of beer which would contain this amount of alcohol would be over two gallons, so that it is easy to

understand that fatal cases of acute alcoholic poisoning are not likely to occur from the drinking of a beverage of this dilution.

Effect of dilution on intoxicating action of alcohol.

So far we have been considering the factor of dilution in its relation to drunkenness, simply as affecting the quantity of alcohol which the drinker consumes, and this, no doubt, is its most important aspect. It has, however, been shown by the researches of Mellanby (*vide* p. 19), that dilution has a further and more direct influence on the inebriating action of alcohol, through its effect in retarding the absorption of the drug into the circulation.

The inebriating action of different alcoholic beverages.

The same observer's investigations also give some support to the popular view that the different sorts of alcoholic beverages may differ from one another in their inebriating effect, for he has found that alcohol taken in the form of stout is absorbed more slowly than when drunk as spirits at an equivalent degree of dilution. Further research is needed to determine whether other sorts of beer resemble stout in this respect, and also whether the different kinds of wine differ from one another and from beer and spirits in the rapidity with which their alcohol finds its way into the circulation. It would also be of practical utility to ascertain whether the action of these several beverages on the nervous system presents any peculiarities which cannot be accounted for by differences in the rate of alcohol absorption.

Practical conclusions regarding advantages of the more dilute alcoholic beverages.

As our practical conclusion, then, from the evidence at present available, we may say that any form of alcoholic

liquor can cause drunkenness, if such a quantity of it is taken, at once or within a short time, as will lead to the presence of the drug in the blood above a certain proportion, which in the case of the average healthy adult, may be put provisionally at from .15 to .2 per cent. From the point of view of the prevention of drunkenness, the superiority of the more dilute beverages, such as the lighter beers and natural wines, is therefore mainly due to the fact that the bulk of the fluid makes it difficult for the drinker to consume a very large dose of alcohol within a moderate period. This, as we saw when referring to the question of fatal intoxication, is an extremely important superiority.

Differences in susceptibility to alcohol.

In the preceding remarks we have had in view the average normal drinker—the person who is neither specially susceptible nor specially resistant to the inebriating action of alcohol. But it is notorious that departures from this average standard are very frequent ; some people are so constituted that they are affected by quite small quantities of the drug, while others can take large doses without showing any signs of intoxication.

Tolerance.

Moreover, as a result of continued use, some degree of tolerance can be acquired, so that the habitual drinker is sometimes able to consume, without becoming obviously intoxicated, quantities of liquor which would cause well-marked drunkenness in a person unaccustomed to the drug. Thus, instances have been known where steady drinkers have been in the habit of taking alcohol in daily doses exceeding 10 cubic centimetres per kilogramme of body weight, that is to say, for a man of 10 stone weight, no less than 23 ounces of absolute alcohol, or well over two pints of whisky at proof, more than enough to kill a neophyte.

We know very little as yet about the bodily changes that accompany the development of tolerance. One factor may be the increased capacity of the tissues to burn alcohol, for it has been shown that when the body has become accustomed to the drug, it can oxidise it much more rapidly, so that, after a given dose, the amount present in the blood does not rise to the same level in an habitual drinker as it would reach in the case of a person who had not acquired tolerance. That this, however, can only be a contributory element is evident from the fact, proved by experiment, that a tolerant animal may show few or no signs of intoxication even when its blood contains enough alcohol to cause well-marked symptoms in an unaccustomed animal.* It is obvious, therefore, that when tolerance has become established, either the access of alcohol to the nervous centres is in some way impeded, or, as is more likely, the nerve cells react less readily to its presence; but we do not know anything of the conditions on which this change depends.

Tolerance not acquired by all cells.

In the case of some other narcotics, as, for instance, morphine, it has been proved that while certain nerve cells acquire tolerance after long use of the drug, others remain as susceptible as at the beginning. This has not been shown to occur in alcohol tolerance, in which it is probable that all nerve cells lose their reaction to the drug in nearly equal measure. But it is certain that, while the nerve cells of the habitual drinker become tolerant to the presence of alcohol, other body cells are less able to accommodate themselves to it, with the result that they are very liable to be injuriously affected, if the development of tolerance in the nervous system leads, as it naturally

* Pringsheim. Biochemische Zeitschrift, Vol. 12, p. 143, 1908.

tends to lead, to the taking of larger doses of the drug. That is why drinkers who have, as they would say, strong heads for liquor, and who can consume a great deal of alcohol without becoming drunk, are very likely to suffer in the long run from some of those bodily disorders we shall presently have to consider in dealing with the subject of chronic alcoholism. And, on the other hand, people who are specially susceptible to the intoxicating action of alcohol are to a great extent protected from excess by that very fact. Just because they are so easily made drunk, they escape the more serious evils of chronic poisoning. Hence from the point of view of general health, the acquisition of tolerance really implies the removal of a protective mechanism—it allows the drinker to use the drug in doses which he could not have taken if his brain cells had retained their normal power of reacting to it.

Special susceptibility to alcohol ; pathological drunkenness.

A further point which should be noted before we leave this question of drunkenness is that under certain conditions, as, for instance, after an injury to the head or after an attack of mental disease, a special susceptibility to alcohol may be developed in persons whose reaction to the drug had previously been normal. And this change may also come about in the later stages of chronic poisoning, especially after an attack of delirium tremens, so that the habitual drunkard, from being more resistant to the influence of alcohol, may become very much less resistant. It is a fact of some importance that this special susceptibility to alcohol, and notably the susceptibility which results from injury, or appears in an advanced stage of chronic alcoholism, is shown not merely in the readiness with which small doses give rise to mental symptoms, but is also very often manifested in the character of these symptoms, which may differ more or

less widely from the symptoms of ordinary drunkenness. Very usually, for instance, there is in these conditions of "pathological drunkenness," as it is called, a special degree of involvment of the highest nervous centres—the parts of the brain whose activity is related to our conscious life—so that prolonged phases of mental confusion with excitement and impulsiveness are more likely to occur than in the intoxication of normal individuals. For this reason the pathological drunkard, especially when his morbid predisposition is due to chronic alcoholism, is very apt to commit acts of a seriously criminal character.

Chronic alcoholism.

Having said this much about acute poisoning by alcohol, we now pass to consider the question of chronic intoxication. As was pointed out in the introductory section, there may be no relation between the acute symptoms set up by a single excessive dose of a drug, and the chronic disorders that result from slower poisoning by repeated and usually smaller doses of the same drug; and this is conspicuously the case with alcohol. The symptoms of drunkenness are due to the immediate action of alcohol in the body, an action the effect of which, as we have seen, is mainly apparent in disturbance of the functions of the brain; when the drug is eliminated from the system, all trace of this action disappears and the patient returns to his normal state.

It is quite otherwise in chronic alcoholism. Here we have to do with changes in the drinker's tissues which may be of a permanent character, and which at all events persist long after the alcohol has been entirely removed from the system; and these changes are not limited to the nervous centres, but may affect in one way or another most of the organs of the body.

Chronic alcoholism due to a generalised devitalising action : its association with other deleterious influences.

It would be beyond the scope of this book to give any detailed account of the disorders which are collectively described under the term chronic alcoholism. Briefly, it may be said that they represent the results of a general devitalising action on the tissues, and that they vary from a relatively moderate impairment of the normal state of the organs to gross morbid changes which ultimately cause death. Of course, the habitual drunkard is exposed during his life to many other deleterious influences besides that of alcoholic excess ; and several of these influences resemble alcohol more or less closely in their mode of action ; so that it may be a matter of considerable difficulty to assess the due importance of the alcoholic factor in the causation of the diseased conditions which are found in specially frequent association with intemperance. This fact has not always been adequately recognised in the past, with the result that many morbid conditions have been set down to the account of alcoholism which are really due, wholly, or in far greater measure, to other causes. The responsibility of syphilis in particular has often escaped recognition in this way, and diseases, such, for instance, as general paralysis of the insane, which we now know to be invariably dependent on syphilitic infection, were long regarded as capable of being brought about by alcoholic excess. Such confusion can occur the more readily because, as pointed out in the recent Report of the Royal Commission on Venereal Diseases, the intemperate drinker, by reason of his lessened power of self-control, is specially prone to expose himself to the risk of contracting these diseases, and, owing to his lowered vitality, is liable to suffer from them in aggravated form.

Moreover, the way in which alcohol acts in chronic intoxication is complex : its injurious effects are only

partially the direct result of the drug entering the system ; they are largely brought about through its detrimental action on the lining membrane of the stomach and bowel, causing chronic catarrh and failure in the action of the digestive juices, and so promoting the absorption from the alimentary canal of poisonous matters (digestive and microbial toxins, as they are termed), which, in healthy conditions of the mucous membrane would be formed in lesser amount, if at all, and would certainly not be allowed to pass so freely into the circulation. It is, indeed, a question whether many of the morbid changes which occur in other organs in the course of chronic alcoholism may not really be secondary to these local disorders in the gastro-intestinal tract ; for it has been found in some experimental inquiries that when alcohol was administered to guinea-pigs, not by the mouth but by inhalation, no visible alterations were produced in the animal's tissues, even when the intoxication was kept up for periods as long as three years—that is to say, during half the average life of an animal of this species.*

Experimental alcoholism.

When these considerations are borne in mind, it will be readily understood that it is very difficult to define the limits of chronic alcoholism, and to distinguish its effects from those of the other morbid influences which may be mixed up with it. Efforts have been made to overcome this difficulty by having recourse to the experimental method ; numerous investigations have been made to determine whether the continued administration of the drug to rabbits, guinea-pigs and other animals will produce in their tissues morbid changes similar to those found in chronic alcoholism in man. There are, it is true, obvious limitations to this method : its conditions are

* Stockard. American Naturalist, Vol. 47. 1913. Proc. Society of Exper. Biology and Medicine, Vol. 11. 1914.

necessarily very artificial, and moreover, the differences between man and other animals, especially in regard to the development of the brain—the organ on which alcohol exercises its most important action—are enormous, so that it is only with considerable reserve that conclusions drawn from animal experiment can be applied to human beings. Despite such drawbacks, however, these researches have given certain positive results of unquestionable value, particularly with regard to the effect of chronic poisoning on the liver and on the reproductive glands. The bearing of the facts will be best brought out if they are considered in relation with the data derived from the observation of alcoholic diseases in man.

Individual variations in susceptibility to chronic intoxication.

The first important point to be noted is that the results of laboratory experiment are in full agreement with medical experience in proving the existence of wide individual variations in susceptibility to the injurious effects of alcohol. Just as instances are occasionally met with where persons have drunk what would be generally regarded as dangerously excessive quantities of alcohol for years, and have yet shown no signs of being the worse in health, so likewise in experimental researches it has been found that some animals do not appear to suffer from daily intoxication over long periods of time, while others of the same species succumb after a few weeks. Individuals, whether experimental animals or men, differ also very widely in the susceptibility of the several tissues and organs to the action of the poison; in one subject the liver may be specially attacked, in another the nervous system, and so on.

Mental disorders in chronic alcoholism; relation of alcoholism to insanity.

Some affection of the mind is usually present in chronic alcoholism, but it is commonly moderate in degree, and

may be shown only in weakened will-power and failure of memory. More intense but transitory disorders occur in *delirium tremens*, and in an allied condition of mental confusion associated with wide-spread nerve-inflammation. In relatively rare instances, alcoholism seems to be responsible for a chronic insanity with persistent delusions, usually of persecution and jealousy. In general, however, the part which alcoholic excess plays in the causation of the ordinary forms of mental disease is of secondary importance: it has been shown that when the two facts are associated, intemperance is more usually a symptom of insanity than its cause.* This is conspicuously seen in certain cases of periodical (or *manic-depressive*) insanity, in which, or in one phase of which, the most obtrusive symptom of mental disorder is an intense and overpowering impulse to alcoholic excess. In these relatively infrequent cases, to which the name *dipsomania* is sometimes given, the patient drinks heavily for a period varying in different cases, but usually of approximately constant length for the same case, and then, when the attack ceases or passes into another phase, he returns to sobriety—a fact, it may be noted incidentally, which goes to show that alcohol has no very strong habit-forming influence.

The following table, which gives the figures showing the changes in prevalence of alcoholism during the years 1913-1918, demonstrates clearly that the number of deaths directly or indirectly attributable to alcohol has no observable relation to the number of cases of certifiable insanity as a whole. The figures relate to women only, so that they are not vitiated by the special conditions affecting men on military service.

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* Mott. Archives of Neurology, Vol. 3, p. 424. 1907.

ALCOHOLISM AND INSANITY (WOMEN ONLY). ENGLAND AND WALES, 1913–1918.

	Convictions for Drunkenness.	Deaths from Alcoholism.	Deaths from Cirrhosis of Liver.	Attempted Suicide.	First admission to Lunatic Asylum.
1913 ..	35,765	719	1,665	988	9,372
1914 ..	37,311	680	1,773	1,049	9,702
1915 ..	33,211	584	1,525	816	9,078
1916 ..	21,245	333	1,163	436	8,850
1917 ..	12,307	222	808	452	8,702
1918 ..	7,222	74	579	400	9,726

Morbid changes in nervous system in chronic alcoholism.

The morbid changes in the nervous system which are found in chronic alcoholism are very variable in character and degree: most commonly there is some thickening of the membranes, with wasting of the nervous tissues, notably in those parts of the brain which are supposed to be specially related to the higher mental activities. These appearances, however, are not distinctive of alcoholism, nor is it possible to see in them an explanation of the nervous disorders of chronic intoxication any more than we can discover, with our present modes of examination, any morbid changes in the brain tissues of the insane which can account for the symptoms of insanity. As bearing on this point, it may be noted that the diseased conditions seen in the brain of patients dead of delirium tremens are quite similar to those just referred to as occurring in cases of alcoholism without such active disorder, and, as in these cases, are neither constant nor very definite. It is evident, therefore, that in chronic intoxication the nervous tissues may be damaged in ways which, while profoundly affecting their intimate constitu-

tion and their healthy functioning, are not revealed in any visible structural change. We have already had an intimation of this fact in the development of tolerance, which is also probably dependent on some obscure alteration in the vital activity of the nerve cells. In the affection of the nerves, especially the nerves of the limbs, which occurs occasionally as a result of chronic alcoholic poisoning, more particularly amongst women, and which is technically known as *alcoholic peripheral neuritis*, degenerative changes are found in the nerve-fibres, and also not infrequently in the related cells of the spinal cord. In animals, after prolonged intoxication with alcohol, some observers have found alterations in the nervous system, affecting both the nervous tissues proper and the smaller blood-vessels ; but the meaning of these changes and their dependence on the chronic poisoning are uncertain.

Disorders of the digestive system in chronic alcoholism.

It is well known that a frequent cause of death in the subjects of chronic alcoholism is *cirrhosis* of the liver with dropsy. An organ is said to undergo cirrhosis when the fibrous connective tissue is increased and there is an associated degeneration of the cells upon which the functions of the organ depend.

Chronic inflammation of the stomach (*gastritis*) is met with in heavy drinkers, especially in those who indulge in large quantities of spirits. It precedes and is, in a great measure, responsible for the disease of the liver. The chronic irritation and subsequent inflammation of the mucous lining of the stomach sets up degenerative changes in the cells which secrete the gastric juice and the hydrochloric acid essential for digestion, while the prevention of bacterial fermentation may be completely absent.

The blood circulating in the blood vessels of the

stomach and intestines is returned into the general circulation *via* the portal vein of the liver, so that the blood in this organ contains poisons absorbed from the alimentary canal to a greater degree than that in other organs, *e.g.*, the kidneys. The continuous circulation of these poisons in the liver gives rise to prolonged irritation of the connective tissue supporting the portal vein, its branches and remote ramifications throughout the organ. A chronic inflammation is thus brought about in this tissue, accompanied by a degeneration of the intrinsic cells of the liver, which at first is enlarged. This enlargement in many cases persists until fatal dropsy sets in, or the more complete conversion of the chronic inflammatory tissue into fibrous tissue may eventually cause such a shrinkage of the organ, that it becomes much smaller than natural, and its surface is so irregular and nodular as to be termed " hobnailed."

In experiments on animals a catarrhal inflammation of the mucous membrane has been set up, similar to that which is seen in the stomach of the habitual drunkard. In certain experiments also changes in the liver, corresponding to those of cirrhosis in man, have been produced in animals by long-continued intoxication with alcohol.*

Other bodily disorders in chronic intoxication.

It is also generally recognized that chronic alcoholism is an important cause of disease in other organs, that it contributes, for instance, to the development of Bright's disease of the kidneys, that it helps to bring about the degeneration of the blood-vessels which leads to apoplexy, and that it tends to promote fatty degeneration of the heart, as well as being a very important cause of fatty deposit on the surface of that organ. All these diseased conditions, however, are met with also

* Kyrle and Schopper. Virchow's Archiv f. patholog. Anatomie, Vol. 215, pp. 309 and 321. 1914.

very often in persons who never take alcohol: they may be brought about by many deleterious agencies, operating singly or in combination; alcoholism is merely one of these agencies.

Alcohol and resistance to infective disease.

The relation of alcohol to infective disease is of a somewhat similar kind: the chronic poisoning, by devitalising the tissues, lowers the defences of the body against microbial invasion; consequently, specific germs, such as those which cause pneumonia and tuberculosis, as well as the ordinary microbes of septic inflammation and blood-poisoning, find a suitable soil. A slight general depressing influence—a chill or a local injury—which would have no harmful effect upon a healthy individual, even if micro-organisms were present, because the vital reaction of the living tissue would prevent a general infection, may be most dangerous to a chronic alcoholic.

It has also been suggested that resistance to infective disease may be prejudicially affected by alcohol when taken in even moderate and occasional doses; but the experimental researches by which it has been sought to establish this view have not given any clear results. On the other hand, there is no evidence in support of the popular belief which attributes to such doses of alcohol a protective value in exposure to infection.

Action of alcohol on the reproductive cells.

In the foregoing remarks we have been considering alcoholism merely as affecting the individual: we have now to refer to the wider influence which it may exert on the stock through its action on the reproductive cells. The earlier inquiries regarding the reality and extent of this influence were mainly directed to determining, from statistical material, whether conditions of defective development are or are not specially frequent in the offspring of

alcoholic parents. Evidence of this sort, however, even if its accuracy were unquestionable and its indications positive and clear—and this can rarely be said of any of the statistical data used in this controversy—would obviously be open to serious criticism, inasmuch as any excessive incidence of defect in the children of habitual drunkards might be due, not to the influence of parental alcoholism but to the presence of a syphilitic taint or to an original faultiness in the stock. On this account it is preferable to approach the question from another point of view, and to rely mainly on such data as are obtainable from the systematic examination of the genital glands in alcoholic subjects, and from breeding experiments on animals. Researches in both these directions have been recently carried out, and have given results which, as far as they go, are definite and concordant.

The state of the reproductive glands in habitual drunkards has been investigated by two independent observers,* who have shown that a condition of wasting of the testicles, with absence or scanty production of the fertilising cells or spermatozoa, is to be found in the majority of male alcoholics dying in the prime of life, while in the female, alterations of a similar character may be discovered in the ovaries. Further, it has been shewn by experiments on rabbits that, by the continued administration of the drug, morbid changes can be produced in the genital glands of these animals of the same type as those which have been observed in chronic alcoholism in human beings.

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* Bertholet. L'Influence de l'alcoolisme chronique sur les organes de l'homme, et sur les glandes reproductrices en particulier. Lausanne, 1913. Also communications by the same author to the International Congresses on Alcoholism at London (1909), and at The Hague (1911).

Weichselbaum. Verhandl. der deutsch. pathol. Gesellschaft, Jena, 1910.

Effect of parental alcoholism on offspring.

The fact that these glands are so frequently and so distinctly affected in conditions of chronic intoxication may suggest that parental alcoholism might react injuriously on the vitality and normal development of the offspring. Recent research has furnished very important direct evidence to the same effect. It has been shown by Stockard,* in a series of experiments in which alcohol was administered to guinea-pigs by inhalation, that the offspring of the alcoholised animals, in comparison with the young of control animals of the same stock, were conspicuously inferior in strength and vitality, and in many instances presented gross abnormalities of organisation. These bad effects were transmitted through several generations, and were, indeed, more pronounced in the later generations than in the immediate offspring of the alcoholised subjects. An important point brought out by Stockard is that the injurious influence of the intoxication may be manifest in the offspring even when the genital glands appear to be quite healthy, thus showing that, although there are no visible structural changes in the germ cells, they have been modified to an extent sufficient to cause them to give rise to defective embryos, which either die at an early stage of development and are absorbed, or, if they survive till birth, are weak, often deformed, and die before they reach maturity.

These patient and carefully-controlled experiments of Stockard have now for some years been available for criticism, and their soundness has not been called seriously into question. In their bearing on the results of parental alcoholism for the immediate offspring, their significance is clear : persistent alcoholic excess, whether in father or mother, diminishes fecundity and increases the liability to

* Stockard, *loc. cit.*
Stockard and Papanicolaou, American Naturalist, Vol. 50, 1916.

stillbirths and to the production of weakly and defective offspring. It seems further beyond doubt that this influence of alcohol on the germ-plasm is transmitted by heredity to further generations not exposed to alcohol. In human society the effects of alcohol itself are so seriously complicated by other influences, whether causally related to alcoholic excess, or independent of it, that it is still quite impossible to obtain clear evidence on a point of this kind from human statistics, however carefully collected and scientifically investigated. It is the more important to have this effect of alcoholic excess laid bare by the results of experiments, in which all other conditions could be kept rigidly constant. While, however, we may safely regard it as, at least, extremely probable that alcoholic excess in human parents, if it could be similarly isolated from complicating influences, would be found to have a prejudicial effect on the number and quality of their offspring, and of the immediate descendants of these, it is by no means so easy to predict the ultimate effect on the race of widespread alcoholic excess in earlier generations. Stockard,* himself, from his later observations on his race of guinea-pigs, concludes that the ultimate result of the adverse influences, originally created by alcohol and subsequently transmitted by heredity, is to produce by natural selection a more robust and efficient stock than that maintained without alcohol. It is legitimate to doubt whether natural selection would produce this effect so clearly in the increasingly complicated conditions of civilised human society. Further, lest any should find, in these results and conclusions, an argument for palliating alcoholic excess, and should urge that sobriety may be good for us and our immediate successors, but bad for our race in the long run, it should be pointed out that the same argument would favour the abandonment by mankind of efforts to protect the race from many other adverse influences. The only practical

* Stockard, *loc. cit.*
Stockard and Papanicolaou, American Naturalist, Vol. 50, 1916.

conclusion, which the eugenist can draw from Stockard's experiments, is the danger which excess of the strictest moderation in alcohol entails for the offspring, and even for their descendants for several generations, until the less resistant types have been eliminated by natural selection, or the effect obscured by crossing with healthy stock.

Causation of chronic alcoholism.

After this brief review of the disorders of chronic alcoholism, the next question to be considered is, under what conditions do these disorders come about? What mode and degree of excess are liable to lead to chronic poisoning? In endeavouring to answer this question we have not at our disposal any direct evidence comparable to what we had when discussing drunkenness; and we must, therefore, be content, at all events for the moment, with such indirect indications as can be gathered from a general survey of the facts.

Continuity of action and excess of dose necessary factors.

The main conclusion that we arrive at in this way is, that there are two essential factors in the causation of chronic alcoholism: first, the drug must be taken in sufficient quantity to exercise an injurious action on the tissues, and second, that action must be more or less continuous. Excess of dose without continuity of action does not give rise to persistent tissue changes; as we have already seen, an isolated bout of drunkenness does not leave any lasting after-effects. Again, the regular use of alcoholic beverages does not induce chronic poisoning so long as only moderate doses are drunk; this is a matter of common experience, and we can see evidence of it on a large scale in the absence, or extreme rarity, of chronic alcoholism in communities where, as in the non-industrial populations of Southern France, Spain, and Italy, alcohol is part of the ordinary dietary, but is drunk in moderation and in the form of natural wines of low strength.

Conditions which promote chronic alcoholism.

In the absence of exact data, we cannot safely go beyond these general propositions, and we shall not, therefore, attempt to make any estimate as to how much alcohol there must be in the blood, and how long its action must be kept up, to exercise a detrimental effect on the vitality of the tissues. For practical purposes it will be sufficient if we endeavour to distinguish the conditions which cause alcoholic beverages to be taken in such excess, with regard to amount and frequency of dose, as appears from actual experience to involve more or less injury to the drinker's health. In a general view, we may summarise the more important of these conditions as follows:—

(i) *Use of the stronger alcoholic beverages.*—When liquors of high alcoholic strength are drunk, there is an antecedent probability that an excessive dose of alcohol may be more readily taken. The man who drinks a light beer must consume some pints of fluid before he gets as much alcohol into his blood as the spirit drinker would absorb from a glass of neat whisky at proof.

In this connection it has also to be borne in mind that, as shown by Mellanby's researches, alcohol is absorbed in the blood more slowly when it is drunk in dilute solution than when taken in concentrated form, and more slowly when drunk as beer than when consumed as distilled spirits. These facts may explain, at all events in part, why drunkenness appears to be relatively more frequent in spirit drinkers than in beer drinkers, though the difference is probably less pronounced than is commonly supposed. In a recent inquiry directed to this point, it was ascertained that amongst 1,505 persons (1,032 males and 473 females) charged with drunkenness, in London and 14 other large cities in England during a period of three weeks, intoxication was attributed to beer alone in 45.4 per cent. of the cases occurring in men, to spirits alone in 42.0 per cent., and

to beer and spirits together in 10.8 per cent., whilst amongst women the proportions were, beer alone, 37.6 per cent., spirits alone, 49.0 per cent., and beer and spirits together, 8.6 per cent. In as much as the amount of alcohol taken in the form of spirits in the whole United Kingdom is only one-third to one-quarter that which is consumed in beer, it is legitimate to conclude from these figures, drawn from the predominantly beer-drinking part of the country South of the Tweed, that there is, in fact, a greater likelihood of immediate excess when the stronger alcoholic beverages are used. The statistical information with regard to the relative importance of the several sorts of liquor in the causation of chronic alcoholism is very scanty, but, so far as it goes, it points even more clearly in the same direction, and is thus confirmatory of the general medical belief that spirit drinking is specially liable to induce alcoholic disease.

Apart from the greater risk of excess of dose when highly alcoholic beverages are drunk, the use of these more concentrated liquors tends, as we have already seen, to promote chronic poisoning, on account of the damage done to the lining membranes of the stomach by the direct action of alcohol in strong solution.

(ii) *Frequent repetition of dose.*—It takes some hours before even a moderate dose of alcohol is completely eliminated from the system ; so that if a fresh quantity of liquor is drunk during this period when the blood still contains a significant percentage of the original dose, the alcohol level in the circulation will rise again. And if further doses continue to be taken at similar intervals, the action of the drug in the body will be kept up persistently.

This is what happens, for instance, in the case of industrial workers who have frequent recourse to alcohol during the hours of labour, as, *e.g.*, dock labourers, butchers, etc. : owing to this frequent repetition of doses, which, taken individually, may be quite moderate, but which by their addition maintain a considerable concentration of the drug

in the blood, drinkers of this class, industrial drinkers as we may term them for brevity's sake, are peculiarly apt to suffer from the chronic effects of alcohol. In this respect, they contrast very strikingly with men engaged in such occupations as coal-mining. The miner's task involves muscular effort which in its character and degree might appear *a priori* to be equally conducive to thirst. The conditions however, under which the work is carried on are such as preclude altogether the possibility of taking alcohol during the hours of labour ; and amongst coal-miners, accordingly. industrial drinking is practically unknown, and alcoholic disease is exceptionally infrequent.

Thus, if we refer to the statistics of occupational mortality published by the Registrar-General (*vide* appendix 3), we see that, while in the case of dock labourers the " comparative mortality figure " for alcoholism is more than three times that for the general male population, the corresponding figure for coal-miners is less than half the same standard, and is, in fact, one of the lowest on the list. There is no reason to suppose that this contrast is due to any difference in general sobriety between the two groups in question—the incidence of drunkenness is very similar upon mining districts and upon seaports—so that it seems reasonable to attribute it mainly to the prevalence of continuous or quasi-continuous drinking amongst dock labourers, and to the absence of that type of drinking amongst the coal miners.

The inference to be drawn from these facts is, therefore, that, in order to prevent the development of chronic intoxication, it is essential that alcohol should not be taken in such frequently repeated doses as will result in the persistent presence of alcohol in the blood—that is to say, that intervals should elapse between the times when alcoholic liquors are drunk, such that the average concentration of the drug in the blood remains well below the point at which there is any risk of injury to the tissues.

(iii) *Drinking without food.*—Food, when taken wit...

alcohol, dilutes it, and so decreases the irritant action of strong alcoholic beverages upon the lining membrane of the stomach; the lack of this protective influence is probably an important factor in the greater susceptibility of the industrial drinker, who commonly takes much of his alcohol on an empty stomach, particularly the early morning dram, or "livener," with which it is customary in some districts to start the day's work.

(iv) *Sedentary Occupation.*—It is popularly supposed that intemperate persons of sedentary habits are more liable to suffer from the effects of alcoholic excess than drinkers engaged in active outdoor occupations. To a certain, though very limited, extent this view is supported by what we know of the conditions which may modify the oxidation and elimination of the drug. Thus we have seen that vigorous muscular exertion causes alcohol to be burned rather more quickly in the body, and also increases the proportion which passes out unchanged in the breath. The effect produced in either of these ways is not, however, so considerable that it can to an important degree protect the drinker from the injurious results of the habitual use of the drug in excessive and frequently repeated doses; and, in fact, as shown by the statistics of occupational mortality already referred to, the death-rate from presumably alcoholic disease is specially high in several of these industries which involve hard muscular labour in the open air. Thus the theoretical advantage which this active sort of work confers on the drinker, in accelerating the removal of alcohol from his body, is in practice much more than counterbalanced by the tendency, which such work creates, to the continued and excessive use of the drug as a supposed aid to labour.

From this point of view the risk of chronic intoxication is in some sort enhanced by what would appear *prima facie* to be a desirable quality in alcohol, viz., its food value. As we have already seen, it can be used to furnish

as much as one-fifth of the total amount of the energy required by the body, so that the industrial drinker, over and above the relief from the sensations of fatigue which the drug gives him, obtains in his alcoholic liquor a supply of fuel food which enables him to reduce substantially his consumption of other forms of nutriment. The fact, therefore, that alcohol has a high fuel value, tends in an important measure to promote its habitual use as a food for very laborious work in substitution for other foods; and as, unlike these other foods, it is not stored in inert form in the body, but remains unaltered in the tissues until it is oxidised, it can exercise for some time a deleterious influence on their vitality.

Habit-forming influence of alcohol.

To complete this examination of the factors which contribute to the development of chronic intoxication, it is necessary to say something of habit in relation to alcohol. A number of drugs, especially drugs of narcotic action, when they have been taken repeatedly for a sufficient length of time, tend to create in the subject a need or " craving " for their continued use; such drugs are described as habit-forming, and the condition existing when the need or " craving " has become established is called the drug-habit. It is to be noted that a drug-habit, in this special sense of the term, means a good deal more than the habit of taking a particular drug; thus, for example, a person who suffers from some chronic or frequently recurring disorder which is relieved by a specific medicine will be likely to use that medicine regularly, but he will not be considered, on that account alone, to have contracted a drug-habit; his need of the drug is due to the persistence of the cause which led him to resort to its use in the first instance—it has not been created by the action of the drug on his system. Neither can we properly bring into the category of drug-habits, in the narrower meaning in which the term is here employed, those instances

where the continued use of a drug has given rise to a sense of need, solely through that general characteristic of our nervous organisation in accordance with which we tend to repeat actions that we have become accustomed to perform. It is true that this influence does enter to some extent into the formation of true drug habits, as it necessarily must in the case of all behaviour which has become customary and agreeable ; but it is obviously a factor of different nature from the specific disposition which is created by the continued action of the drug, and gives to the drug craving its distinctive character.

Factors which may contribute to the formation of the alcohol habit.

In the development of the alcohol habit, all these factors play their parts. The habitual drinker takes alcohol primarily for the sake of the agreeable effects produced through the nervous system, because he finds that it relieves the sensations of fatigue, and because he believes that it gives him increased energy for his work ; the return or persistence of these motives undoubtedly contributes to the regular use of alcohol. Similarly, some persons are said to " fly to drink " when they are worried or in pain. In these instances alcohol is taken with the definite object of obtaining relief from some disability. In other instances the chief factor in drinking seems to be an attitude of mind which is comparable with that induced by the continued repetition of any other act which becomes habitual in the ordinary sense. Such is the case of the drunkard who cannot pass his usual public-house or meet his ordinary boon companions without having a glass ; his conduct may be largely an instance of habit, and his difficulty in breaking it off may be scarcely greater than that of the loafer in deserting his usual street corner. But while these factors undoubtedly play an important part in the development of habitual drinking, there can be no question that the continued abuse of alcohol

leads in many instances to changes in the mental and bodily functions which create a need or craving for alcohol. The depression which is present during the recovery from one drinking bout may be relieved by further indulgence and thus lead to the continued use of the drug. The most striking examples of craving are seen in secret drinkers, in whom the abuse of alcohol is somewhat similar to that of morphine in morphine-takers.

Tolerance and abstinence symptoms in drug-habits.

In the case of some habit-forming drugs, the drug gradually loses its power and no longer induces the action which followed its first administration. The best example of this is offered by morphine, the most active ingredient of opium. The morphine-taker, or morphinomaniac, through the habitual use of the drug, becomes less and less susceptible to its immediate effects, that is to say, he acquires tolerance with regard to it, and, by reason of this tolerance, he tends constantly to increase his regular dose. Further, when he is deprived of his usual allowance, he experiences acute discomfort, and, if the drug is suddenly and completely cut off, he sometimes presents symptoms of serious collapse, which may even end fatally if morphine is not administered to him.

Tolerance and abstinence symptoms in drinkers.

The development of tolerance, then, and liability to abstinence symptoms are often the accompaniments of the true drug-habit. The degree, however, to which they may be present varies very widely in the case of different drugs. How does the matter stand with regard to alcohol? As we have already seen, the continued use of alcohol produces tolerance, though never to the extent that may be reached in the morphine habit. And alcohol

also may induce such a condition in the drinker that its complete and sudden withdrawal will give rise to a feeling of urgent need, or "craving," for the drug, which is usually regarded as, and probably is, at least in part, a genuine abstinence symptom. Though very lurid accounts of this craving are sometimes given by neurotic drinkers, it would appear that ordinarily the feeling, in so far as it really is such a symptom, is very much weaker than the craving which habitual users of other drugs experience as a result of abstinence. Thus, drunkards in prisons and other institutions where liquor is not obtainable, complain much less of discomfort from the lack of alcohol than do smokers of that due to the prohibition of tobacco.

Delirium tremens not due to abstinence.

It has also been suggested that abstinence symptoms of a more definite and graver sort may occur in alcoholic subjects, and, more particularly, that the abrupt cutting off of the drug in the case of a heavy drinker may precipitate an attack of delirium tremens. This has been disputed, however, by many authorities, and several arguments have been brought against it. Thus, delirium tremens is of very rare occurrence in institutions where, as in the majority of inebriate retreats, it is the regular practice to stop all alcoholic liquor immediately on the patient's admission. Further, when the disease has developed, its course is not affected by the administration of alcohol, whereas the abstinence symptoms resulting from the suppression of other drug-habits, as, *e.g.*, the morphine habit, are relieved at once when a dose of the drug is given. Finally, recent investigation has shown that in many cases of delirium tremens, the fluid which bathes the brain and spinal cord—the cerebro-spinal fluid—contains appreciable amounts of alcohol, so that

evidently its presence in the nervous system does not prevent the onset of an attack.*

Relatively slight habit-forming tendency of alcohol.

Alcohol thus differs from such habit-forming drugs as opium and morphine in the fact that its sudden with drawal causes less severe symptoms, and that no high degree of tolerance is acquired by its prolonged use. But these are differences in degree rather than in kind. And it is to be added that our experience of morphine-takers in this country is limited to severe cases comparable to the confirmed drunkard. In each case the habit of abuse may in part arise from the persistence or recurrence of the conditions and circumstances which originally led to recourse to the drug. But the habit of excess once formed tends to become stronger through the enfeeblement of the will which results from the continued action on the central nervous system and lessens the power to resist the invitation of the narcotic.

* Demole. L'Encèphale, January, 1914.

CHAPTER IX.

Alcohol as a Medicine.

Alcohol in its various preparations has always played a part in the treatment of many diseases, and it is only in recent times that its usefulness has been questioned. The use of alcohol in hospitals has been much reduced, without injury to the patients, and in some clinics it has been abandoned altogether. There is no doubt that too great importance was laid on the value of alcohol in illness formerly, and the only question at issue is whether its prescription has reached the proper limits or should be still further curtailed. The facts that alcohol is, at the same time, a powerful and rapidly acting drug, and a constituent of the regular diet of a large proportion of the white races, have made it pre-eminently the popular domestic remedy for many of the minor ailments which afflict mankind. It must not be forgotten that, until recent years, alcohol and opium were practically the only narcotics known in Western civilization: with the introduction of the more modern drugs of this class, the use of alcohol to reduce nervous excitement naturally diminished.

Some of the therapeutic indications for the use of alcohol have been mentioned incidentally in the other chapters of this book in dealing with its actions on the different bodily functions. It has seemed desirable, however, to gather into a separate chapter the evidence as to the value of alcohol as a therapeutic agent, even at the risk of some repetition of what has been said elsewhere. Whatever opinion may be formed as to its value or its danger as an article of ordinary diet for the healthy, it is still a duty to consider independently its place in the treatment of the sick.

In the first place, it may be said that alcohol does not act as a specific cure for any disease. The effect, for example, of quinine on malaria, or of emetine on amœbic dysentery, is

due to a destruction of the infecting organisms. Alcohol has no action of this kind, and what therapeutic effects it possesses are wholly the result of those actions which have been considered elsewhere in this book. It follows that any value which alcohol may possess as a medicine must be due to its power of alleviating symptons and of assisting the natural recuperative powers of the body.

In discussing the therapeutic value of alcohol, we are not concerned with the effects of excessive doses, which are considered in the chapter on " alcohol as a poison." We have only to consider the value for the sick person of its action as a food and as a drug. Elsewhere we have discussed the significance of these actions for normal life Here the problem and the point of view are different, though the actions are practically the same. For example, we have seen that the associated drug action limits the value of alcohol as a food for the healthy ; it will be clear, however, that the same association, which no other food or drug presents in like degree, may give alcohol a special position as a remedy. Again, it was of importance to recognise that the action of alcohol on the nervous system is essentially narcotic, and that its effect on the higher faculties is inimical to precision in mental or muscular activity ; it must be remembered, however, that this blunting of the fine edge of sensitiveness, this relaxation of mental tension and control, may be of the highest value in the treatment of disease. We have, therefore, to take one by one those actions of alcohol for which clear evidence was found—its narcotic action on the brain and nervous system ; its dilating action on the blood vessels of the skin ; its carminative action on the movements of the alimentary canal, reducing the tendency to painful and irregular contraction ; its action as a readily available food. We have to see what value each may have in the treatment of the sick or convalescent, not forgetting that a combination of the actions, rather than any one by itself, may be of special value in some cases.

The mildly narcotic action of alcohol is probably the most important from the therapeutic point of view. In many cases of illness the condition of the patient is aggravated and his recovery retarded by anxiety as to the course and outcome of his malady, and by worry concerning his affairs and his family. Such anxiety may definitely impair the prospect of recovery, and in so far as alcohol allays it and promotes rest and confidence, it has a definite therapeutic value. There is no room for doubt that it frequently has such an effect. We have seen elsewhere that a very characteristic feature of its action on the normal subject is the self-confidence which it engenders. In an experiment on the effect of a moderate dose of alcohol the subject believes that his performance of the test has been unusually good and rapid, and is only convinced of the contrary by subsequent inspection of the record. Whatever may be the effect of such misleading confidence in the normal business of life, it often has a real value for the sick. Even when a physician is unable to find any physical sign of improvement, the fact that the patient feels stronger and less anxious tells in his favour. In promoting sleep and improving appetite alcohol performs a real service, and the relaxation of nervous tension which it produces may even contribute to the reduction of a febrile temperature. Even if it fails to modify perceptibly the progress of the disease, alcohol will often make the patient's condition less distressing to himself.

This action of alcohol is shared by other narcotic drugs, but it may often be the best one to administer, because by suitable dosage its action can be rendered mild and prolonged without interfering with the normal action of the stomach and bowel, or having a depressant action on the respiratory centre. It has the advantage over some other narcotics, that no rapid increase of the dose administered is necessary for the production of the desired effect, the tolerance acquired for alcohol being relatively slight and slow in development. The fact that it has a food value must also

be taken into account in dealing with conditions in which the patient has little power of taking ordinary nourishment.

This mildly narcotic action of alcohol finds its chief use in the treatment of acute infection accompanied by fever. Formerly such diseases, notably pneumonia, typhoid fever and septic conditions, were habitually treated by administering large quantities of alcohol, on the mistaken view that it had a more or less direct and specific action on the infection. We have seen that there is no ground for such an assumption. The indiscriminate treatment of all such cases with wines and spirits has fallen into disfavour and has nothing to recommend it. The course of the disease is not shortened and the percentage of recoveries is not increased by such treatment, nor is there any uniformity in the relief of the patient's distress. In such cases alcohol given skilfully and rationally may have great value, but it must be prescribed with care and judgment like any other narcotic, and not administered at the discretion of the patient or his friends.

During convalescence from an acute infection, or during the course of a more chronic illness, alcoholic liquors may again have some value in improving the appetite. All the available evidence is against the view that alcohol has any directly beneficial action on the digestive organs, but it may promote digestion and assimilation by removing the influence of the anxiety and tedium associated with the patient's condition. A more pleasurable anticipation of meals has in itself a favouring influence on the action of the digestive organs. The prescription of alcohol under such conditions again needs judgment and discretion. The experience of its power to mitigate anxiety, and to replace an abnormal sensitiveness to discomfort and tedium by a feeling of contentment, may be dangerous to a neurotic patient.

Apart from this action on the mind, which constitutes its chief claim to value in medicine, we have seen that alcohol has a certain definite though limited food value. We have discussed elsewhere the undesirability of regarding

it as a food for the healthy man ; but in sickness, in which its action on the brain may be really beneficial, and in which the power of taking ordinary foods may be greatly reduced, the food value of alcohol becomes of importance. A patient lying in bed requires in food the daily equivalent of rather less than 2,000 thermal energy-units, or " calories," to balance his necessary energy expenditure. An ounce of spirits of proof strength gives about 80 calories. The recent work of Mellanby, which has been mentioned elsewhere, suggests that the body of a healthy man is capable of dealing with as much as $\frac{2}{3}$ of a pint of proof spirit in 24 hours ; this would yield about 1,100 calories on the above basis—a very substantial part of the total energy requirement of a patient in bed. It is not, of course, suggested that alcohol is, or ought ever to be given to the sick person in this amount, or that it should be used in place of other foods when these can be taken. It seems clear, however, that it can help the sick man to tide over a period of relative inanition, in which other foods cannot be taken. It is true that alcohol is readily absorbed and requires no activity of the digestive organs ; the same, however, is true of grape-sugar (glucose). The special position of alcohol, and its value in maintaining the strength during a critical period of an illness, lies in the fact that it is at once a narcotic and a food. When the main object of the treatment is to control the restlessness and morbid anxiety of the patient, the association with this action of even a limited food value is not without importance.

When alcohol is given during convalescence on the other hand, or during more chronic illness, little importance can be attached to its food value as such. Indeed, if its use should lead the patient to take less of more normal foods under such conditions, it would be disadvantageous. Only in so far as it improves the appetite and the digestion, and leads to the more ready acceptance and assimilation

of the food which can repair the wastage of disease, has it any serious influence upon nutrition.

An instance of the use which may be made of the direct food value of alcohol has come into prominence in connection with the treatment of diabetes. In the modern treatment of this condition, all ordinary food is often withheld for several days at the outset of the course. It is found that the patient can be assisted through this preliminary period by a daily ration of alcohol. Doubtless the action on the nervous system is a factor in this effect; and in any case the alcohol given cannot be sufficient to balance more than a part of the energy expended even by the resting body. Nevertheless, the energy which alcohol can provide, when administered in small and dilute doses, is of definite assistance under such conditions. Even when the recently discovered "insulin" is used, which enables an equivalent effect to be obtained without such drastic dietary restriction, alcohol may still form an important item in the scientifically adjusted diet, at least in the early stages of treatment.

The popular use of alcohol for griping pains, and for abdominal discomfort generally, is probably related to the carminative action which it shares with other substances acting as mild irritants to the gastro-intestinal mucous membrane, such as various essential oils, peppermint, cloves, &c. Its apparent effect in this direction is doubtless enhanced by the action on the brain, rendering the subject less keenly aware of the discomfort. From the medical point of view it can only be said that there are many alternatives equally effective, and that the recourse to alcohol to allay the minor discomforts of life, whether physical or mental, is probably the starting point for many cases of habitual intemperance, especially in women.

Lastly, the flushing of the body surface which alcohol produces probably has some therapeutic usefulness. We

have mentioned elsewhere the value of this action to the victim of severe exposure to cold, as by immersion, when once he has been placed under conditions supplying external heat to the body. Popular usage credits with a similar value a dose of spirits and hot water, taken in bed, in the initial stages of a " common cold "—an infective catarrh of the respiratory passages. In that it assists the diversion of the blood to the vessels of the skin, thereby relieving to some extent the congestion of internal organs and promoting a salutary perspiration, there is no reason to doubt that alcohol may be of some benefit when used in this way.

We may summarise the known therapeutic uses of alcohol as follows :—

(1) Its main value is due to its narcotic action, by which it allays excitement and distress, and induces rest and comfort, and thereby often ameliorates other symptoms indirectly.

(2) Its limited food value may become important in association with its narcotic action, under conditions in which ordinary nourishment cannot be taken.

(3) By diverting blood from the internal organs to the surface it has an adjuvant action to the application of external warmth in warding off or abating the effects of the common catarrhal infection known as a " chill."

This being stated, it is of no less interest to consider some of the actions which are attributed to alcohol with no adequate reason. In the first place, the popular belief in alcohol as a remedy is largely based on the illusion that it has an important stimulant action on the heart, on the respiration, and on the vital activities in general. Rational medicine, as we have seen, has long abandoned this belief, but it still lingers in popular practice. When a person becomes suddenly unconscious from any cause—whether

syncope (fainting) from fright, pain or exhaustion, epilepsy, apoplexy, suffocation, or concussion from a fall on the head —the first impulse of the sympathetic bystander is usually to force spirits between the teeth of the victim. The irritation of the throat by the pungent liquor, the excitation of coughing by its trickling into the larynx, may seem to accelerate the outward signs of returning consciousness, but there is no reason to suppose that the treatment does the patient any good. The supposition that the alcohol stimulates the action of a failing heart has no basis in ascertained fact. When the subject is recovering from syncope due to fright or pain, the sedative effect of alcohol may be of use in preventing a recurrence, but the indiscriminate administration of alcohol to a stranger found unconscious from an unknown cause is to be deprecated; it is unlikely to do good, and it may well do harm.

Another popular illusion, which we have mentioned elsewhere, is that which credits alcohol with a specific stimulant action on assimilation, so that its regular use is supposed to impart a physical robustness unattainable without it. With this may be classed the more dangerous belief that alcohol has a protective action against infection. We have seen that it may have real value in the treatment of an acute fever, when taken under skilled advice; it is the more necessary to repudiate with emphasis the supposition that its occasional or habitual use has any prophylactic effect. On the contrary, there is good evidence that the use of alcohol, in excess of the strictest moderation, definitely weakens the power of resistance to an infection such as that of influenza or pneumonia. The prognosis in pneumonia for the free user of alcohol is always bad; his habit has weakened the natural power of resistance, and has cut him off from the benefit which the abstainer or strictly temperate user may obtain from the unaccustomed action of the drug at a critical period of the disease.

We may, therefore, conclude that alcohol, when properly used, is a genuine therapeutic agent. If its use in other connections were unknown, it would still be a valuable item in the pharmacopœia. Its true utility, however, is liable to be obscured by the unthinking attribution to it of various activities which it does not possess, and by the popular custom of recourse to it in almost every kind of emergency.

CHAPTER X.

Alcohol and Longevity.

Does "moderate" drinking affect the average duration of life?

Thus far we have examined the subject in the light of direct experimental pathological or clinical researches, and our task has not differed in kind from that of any writers on physiological or medical questions. But a discussion of the properties of alcohol is more or less intimately related to that of various sociological and economic problems, the elements of which can rarely be subjected to the process of isolation and intensive study which is the essence of experimental science. Hence arises the appeal to other kinds of evidence. In popular discussions a good deal of use has, for instance, been made of statistics. Some of these refer to matters which do not come within the scope of our inquiry, such as the relationship between alcohol and crime; but one of the subjects which has been treated statistically calls for some discussion, namely, the belief that "moderate" drinking shortens (or lengthens) life on the average. This seems the most definite point of a mass of loosely defined or undefined notions respecting the value of alcohol as an habitual beverage. Many people think that a daily glass of beer, wine or spirits "does them good"; others are not less confident that the use of such substances does harm. Some of the implications of these statements have already been noticed, but one remains for individual attention.

Every reader of these pages must have seen a paragraph describing an interview with some aged man (by preference a centenarian) where the person interviewed attributes his length of days to (*a*) total abstinence from

alcohol or tobacco, or (*b*) absolute regularity in the daily consumption of—say—one pint of beer and one pipe of tobacco. Again, beyond this anecdotal substitute for scientific evidence, one finds statements describing the heavy mortality suffered by, let us say, publicans and inn servants; the inference, whether expressed or implied, being that they have shortened their lives by the abuse of alcohol; or, on the other hand, we see quoted the low death rates of the clergy, it again being suggested that the large proportion of total abstainers from alcohol to be found in this class is responsible for the advantage enjoyed. The wide currency of such statements and implications makes it incumbent upon us to inquire whether there really exists any evidence upon which scientific conclusions can be founded with reference to the relation between a habit of consuming moderate quantities of alcohol and longevity.

Nature of available evidence.

The extreme difficulty of the subject can be best displayed by considering the kind of data that would need to be provided for a solution on the experimental lines of the work used as a basis for the earlier chapters of this book.

In effect we should require to have at our disposal a number of men or women of like ages, similar ancestry, occupations and civil condition. We should divide them at random into two groups: the members of one group would receive a fixed quantity of alcohol daily, and the fates of all would be recorded from the time of beginning the experiment until everyone was dead. Raymond Pearl has recently claimed to possess material "which substantially meets all of the requirements" just stated*. and we shall shortly discuss this claim. Before doing so, however, we must examine certain older evidence which

* Starling, The Action of Alcohol on Man, p. 239, 1923.

has been frequently quoted. As everybody knows, nearly all insurance companies take special pains to learn the state of health and habits of persons whose proposals are entertained, while there are some which classify separately policy holders who are or are not total abstainers from alcohol. An important example is the United Kingdom Temperance and General Provident Institution. The scientific papers dealing with this special case are cited in the footnote, and must be examined by a reader who wishes to master the somewhat technical problems which can here only be sketched in outline.*

Experience of the United Kingdom Temperance and General Provident Institution.

This office accepts, at the same premium, abstainers from alcohol and non-abstainers, but, after acceptance, the records of the two classes are kept apart, bonuses being declared separately for each class in accordance with its mortality experience. This is to say, that no immediate inducement is held out to entrants who are abstainers; if they do derive any advantage in the long run, it will be because their average longevity is greater, so that their section of the office earns larger bonuses.

Now among males insured by this company (whole-life policies) it was found that 26.4 per cent. fewer deaths occurred among the abstainers than would have taken place had they died at the rate observed in the class of non-abstainers. This great difference does not mean that the non-abstainers were bad lives; as a matter of fact, their mortality was almost the same as experienced by the clients of the 23 British Offices whose pooled

* Moore, Journ. Institute of Actuaries, Vol. 38, 213, 1904. Lidstone, *ibid.* p. 273, 1904. Andrae, Berichte d. 5ten. Internationalen Kongresses f. Versicherungs-Wissenschaft, p. 491, 1906.

experience over the years 1863-1893 formed the basis of a widely used table of mortality for insurance purposes (that is, a table showing the chance of a person dying at various ages). To use a statistical average which is possibly more vivid than a mere comparison of percentages of deaths, we may take the expectation of life at age 30, that is, the average number of years lived by persons after the thirtieth birthday. According to the experience of the total abstainers, this is, on the average, a little more than 39 years, while for the non-abstainers it is some 3½ years less; indeed, only one life office, viz., the Clergy Mutual, has recorded an expectation of life superior to that of the Total Abstainers of the United Kingdom Temperance and General Office.

Thus far we have considered only males having ordinary whole-life policies. The experience of the office with women was not so extensive, and the difference between the two classes, abstainers and non-abstainers, although in favour of the former, was not significantly so; they had only 3 per cent. fewer deaths than their fellows (all these comparisons naturally allow for differences of age). The data for Endowment Policies (the popular modern form of insurance in which the sum assured is payable at a certain age or at death, whichever comes first) showed a great advantage among the abstainers (18.2 per cent. fewer deaths than expected), but not so great an advantage as seen in the whole-life policies.

Difficulties in interpretation of the experience of the United Kingdom Temperance Institution.

There is evidently no reasonable doubt that the abstainers insured in this office do, on the average, live longer than the non-abstainers, but it would not be scientific to attribute the result solely to the fact of abstinence from alcohol without further analysis. Insurance statistics have to be

interpreted with great care, owing to the influence of selection and collateral social conditions. Thus, it has been pointed out that the number of policies in force in the abstainers' section of this office increased by 29 per cent. between 1882 and 1902, while the number of non-abstainers' policies diminished in the same time by 23 per cent. The consequence was that the experience of the abstainers was necessarily somewhat more favourable than that of the non-abstainers from an assurance standpoint, for two reasons: (1) It contained a larger proportion of recently selected lives, *i.e.*, persons who had been more recently medically examined; (2) these persons lived during a period of lower general mortality, viz., after rather than before 1882. It is of course obvious that a man aged 35 is more likely to die within a year if he had insured ten years earlier, when 25, than if he had been accepted by the insurance doctor when 34 years old, since he has had time to fall a victim to a disease which the doctor would detect at his examination, but could not predict several years earlier. Again, we know that the expectation of life for all classes has improved with time, in consequence of new medical discoveries which benefit all, and of our modern higher standards of public and personal hygiene.

It is not possible to measure the effect of this difference, but it is proper to state that when the statistics were limited to the period ending in 1882 (the whole data published relate to the years from 1848 to 1901), the abstainers still had an advantage, although for that period the above mentioned factors should rather tell against them, because during the first eight years of its existence the office only accepted abstainers, so that there would have been proportionally more new policies among the non-abstainers.

Another criticism from the insurance standpoint is directed to two peculiarities in the experience of this office. The first is that the ratio of death rates of males to death rate of females (abstainers) is altogether unlike

that found in other offices, the female mortality being, proportionally, much too high. The second is that the mortality experience of the abstainers holding endowment policies was not appreciably better than that of the abstainers holding whole-life policies. Both these facts have suggested to a well-known Continental actuary (Andrae) that the abstainers were, at the time they insured, " select " lives. Thus, the proportion subsisting between male and female rates of mortality must be chiefly due to the differences of liability to certain diseases and accidents dependent upon sex itself and to secondary sexual consequences, such as occupation, general habits, etc. It is not easy to see why this *proportion* should be changed if *both* men and women abstain from alcohol. Again, all other offices have found that persons who take endowment policies die at lower rates, on the average, than do those who take life-long policies. The usual explanation given is that *self selection* is important. Anyone who thinks, either because many of his relations died young, or perhaps because of some private habits or intentions which do not come within the scope of an insurance company's inquiries, that he will not live long, is not likely to pay the higher premium required for an endowment policy, so that the endowment policy holders are twice selected. Naturally we cannot think that abstainers have less powers of self selection than non-abstainers, so, in the opinion of the critic, we must conclude that the whole-life policy holders were already a select class when they insured, and that their lower rate of mortality may not have had anything to do with their lifelong abstinence from alcohol.

It would be exceeding the limits we have assigned to this statement were we to discuss the *theoretical* arguments in support or in rebuttal of this criticism. It does not seem practicable to apply any objective test which could give a decisive answer, and therefore we cannot regard the experience of the office as conclusive.

Possibility that " non-abstaining " group may include some heavy drinkers.

There are two other criticisms the force of which cannot be fully estimated. There is no doubt at all that *excessive* indulgence in alcohol does very greatly shorten life. But in any large group of persons who are not total abstainers there must needs be found, in the long run, a proportion, perhaps a very small proportion, but still some, giving way to circumstances and becoming seriously intemperate. Such persons will, on the average, die below the normal age, and their unfavourable mortality experience must go to swell the balance of deaths in the general section. It is, of course, impossible to measure the significance of this fact, but in the present state of knowledge, we cannot neglect it without begging the question which we really wish to answer, viz., whether *moderate* drinking shortens life or not ?

Risks of venereal disease and accident in non-abstainers.

Also we must bear in mind the conclusion of the Royal Commission on Venereal Diseases, that the abuse of alcohol plays an important rôle in the spread of venereal disease.* A single lapse due to the loss of self-control consequent upon convivial excess may lead to infection with disease which shortens life greatly, and such cases would also help to explain the difference between life prospects of abstainers and moderate drinkers. A like remark applies to various forms of violent death, as in street accidents.

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* Some statistics compiled by Colonel Harrison do not, however, suggest that the rôle of alcohol is predominating. Of 1,256 patients in military hospitals for venereal diseases, 24 per cent. were total abstainers and only 10 per cent. admitted that they were drunk at the time of exposure to infection. (Starling, " The Action of Alcohol on Man," p. 159.)

Evidence afforded by family histories.

As we have pointed out, an insurmountable defect of Life Assurance data is the lack of a continuous record of individual experiences. Of those not abstainers we have no knowledge after their admission except the date of death or withdrawal; even of the abstainers, we know—after the entrance examination—no more except that they continued to abstain from alcohol.

In the course of an investigation in Baltimore, Prof. Raymond Pearl has accumulated much information respecting the habits of a large number of persons whose histories were followed down to death. In his opinion—an opinion which the wide experience and high scientific reputation of Prof. Pearl justify us in accepting unreservedly—the information in these records is both accurate and comprehensive, while the method of selecting families for observation and the economic circumstances of these families were such that, in comparing those persons who did and those who did not use alcohol, no risk is run of contrasting groups differing materially in any other respect than that of the habit under examination. Confining his examination to persons who died after the age of 20—a clearly justifiable limitation—Prof. Pearl had at his disposal full histories of 1,259 men and 788 women. These he has classified in three groups. (*a*) Total abstainers. (*b*) Moderate and occasional drinkers. (*c*) Heavy or steady drinkers. Prof. Pearl has placed in his second group all " whose drinking habits in the opinion of family and friends were very moderate in respect of amount consumed and not entirely regular or steady in respect of frequency. Here were included persons who took ' an occasional glass of beer,' the labourer who at irregular and not too frequent intervals took a drink of whisky or other spirits. The person who made it a regular habit to take wine or beer with meals, even though the amount so taken was never excessive,

was placed in the next higher class, the 'heavy or steady drinkers.' This was done on the ground that a *steady* daily drinker, even in moderate amounts at any one time, consumes in the course of a lifetime a good deal of alcohol."* Prof. Pearl has compared the three groups, using methods similar to those adopted in the analysis of the Life Assurance data, and finds that while his third class, "heavy or steady drinkers," experience a much higher rate of mortality than either of the other classes, the "moderate and occasional drinkers," particularly in the case of women, had a slight but fairly uniform advantage over the total abstainers.

Naturally an investigator is entitled to group his data into whatever classes he thinks appropriate, provided the definitions of the groupings be unambiguous. We can therefore merely express our regret that Prof. Pearl has adopted a method of classification which deprives us of nearly all the benefit which we had hoped to derive from his admirable material.

We should not indeed have supposed that the most convinced advocate of total abstinence would have maintained that the occasional use of alcoholic beverages in a manner qualifying for admission to Prof. Pearl's second class would be likely to shorten life to an extent capable of being statistically demonstrated. Indeed the answer to such a question seems to us of hardly any practical importance. The really serious question, the one which, as we have pointed out, Assurance data do not enable us to answer in any convincing manner, is whether moderate drinking, using the word moderate in its colloquial sense, is prejudicial to longevity. Are a daily pint or two of beer, or a daily bottle of claret, or a few glasses of whisky and soda *per diem* harmful? Prof. Pearl's analysis, if we have correctly interpreted his method of classification, throws no

* Starling, *op. cit.*, p. 243.

light at all upon this fundamentally important practical point. His third class contains in unstated proportions those who in general usage would be termed " moderate " and those who would be termed " heavy " drinkers. The only use therefore to which we can put Prof. Pearl's data is to test by them the validity of the inferences suggested by the simple dichotomy of abstainers and non-abstainers which is the only division applicable to the Assurance office material. Using the material presented in Prof. Pearl's article, combining his two non-abstaining groups (the method of calculation is stated at the foot of the table), we reach the results set out in the following table.

English Assurance Data (Males).					Professor Pearl's Data (Males).			
1	2	3	4	5	6	7*	8	9
Age.	Average No. of years lived by *Abstainers* after reaching the age stated in Col. 1.	Average No. of years lived by *Non-Abstainers* after reaching the age stated in Col. 1.	Difference between Col. 2 and Col. 3.	Percentage the difference is of the *Non-*Abstainers average.	Average No. of years lived by *Abstainers* after reaching the age stated in Col. 1.	Average No. of years lived by *Non-Abstainers* after reaching the age stated in Col. 1.	Difference between Col. 6 and Col. 7.	Percentage the difference is of the *Non-*Abstainers average.
30	38·83	35·07	3·76	+ 10·72	33·25	30·05	3·20	+ 10·65
35	34·60	31·16	3·44	+ 11·04	29·67	27·06	2·61	+ 9·65
40	30·33	27·36	2·97	+ 10·86	26·67	24·41	2·26	+ 9·26
45	26·10	23·67	2·43	+ 10·27	24·07	22·24	1·83	+ 8·23
50	22·02	20·11	1·91	+ 9·50	20·81	19·31	1·50	+ 7·77
55	18·13	16·72	1·41	+ 8·43	17·65	17·55	0·10	+ 0·57
60	14·55	13·57	0·98	+ 7·22	14·12	15·00	− 0·88	− 5·87

* These figures are the weighted averages of Professor Pearl's two series of means (deducting the attained age). For instance, one reaches the figure for age 30 by multiplying 63·35 (mean for " Moderate and Occasional " group) by 449 (No. in that group), adding the product to 57·00 (mean for " Heavy or Steady" group), multiplied by 487 (No. in that group) and dividing the sum by 449 + 487. The result is 60·05 from which is subtracted 30, the number of years already lived. It is thought that these figures are *roughly* comparable with those of the Assurance Experience although the latter are deduced by a wholly different method.

It will be seen that the percentage advantage of the non-abstainers is, at earlier ages, of the same order of magnitude as found in the Assurance data. The figures, based on relatively small numbers, are more irregular, and the diminution of advantage at later ages possessed by abstainers is more definite, but, as a whole, the two sets agree remarkably well.

Prof. Pearl's data are, as he points out (*op. cit.* pp. 248-250), subject to certain technical objections, but he appears to us to meet those objections adequately and, in any event, the technical criticisms to which his material is liable are of quite another kind than those to which the Assurance data have been exposed. Consequently we are of opinion that Prof. Pearl's results go some way to diminish the hesitation with which we have accepted the face value of the Assurance Companies' data in the present connection. Fortunately, however, it is in Prof. Pearl's power to reclassify his data and we hope that he will see his way to extend his analysis and to calculate separately the statistical constants typifying that portion of his records which relates to "moderate" drinkers, defined in a manner more consonant with the ordinary usage of the world.

Until this has been done, and until it has been shown that consistently moderate drinking, in the ordinary sense, does not affect longevity, we think the effect of Prof. Pearl's research is to strengthen the *prima facie* case founded on Assurance data, although we are not prepared to attribute decisive importance even to so carefully compiled a series of records as this. Apart from the technical criticism referred to above, there is some evidence (*op. cit.* 256) of racial heterogeneity, an excess of persons of Slavonic origin and a defect of British in Prof. Pearl's "moderate and occasional" group. We do not think this affects the use we have made of the figures, but it is proper to mention the point.

Mortality of persons engaged in the liquor trade.

We have now examined the most important direct evidence relevant to our subject and pass to the consideration of collateral evidence. In the first place, something must be said of those whose employment brings them into close contact with alcohol. It is, however, unnecessary for us to devote much space to this, because most readers will be acquainted with the figures of the Registrar-General, often quoted in the press, showing the heavy mortality experienced in the liquor trades.* According to the published statistics of a large insurance company (the Prudential) the expectation of life of insured persons belonging to the liquor trades is at age 30 as much as 15 years less than that of the abstainers noticed above, and, indeed, many years short of the average for all males as computed in the Registrar-General's life tables for England and Wales.† The data of the Actuarial Society of America‡ also show that persons employed in liquor saloons die at very high rates. It was found that proprietors, managers and superintendents of liquor establishments who did not attend the bar, experienced a mortality which was 135 per cent. of the standard rate; when they did attend the bar, the percentage rose to 178 per cent., while the death rate from cirrhosis of the liver was sixfold the normal rate.

These figures, of course, confirm the view, which perhaps hardly needed statistical confirmation, that excessive opportunities for indulgence, on the principle "how oft the sight of means to do ill deeds makes ill deeds done," will be attended on the average with special risks to life

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* See Appendix 3.

† McDonald, Berichte d. 5ten. Intern. Kong. f. Versicherungs-Wissenschaft, p. 517. 1906.

‡ Medico-Actuarial Investigation of Association of Life Assurance Medical Directors and the Actuarial Society of America. 3 Vols. New York, 1912-13.

and health. But the statistics do not tell us much more ; we cannot infer from them that a publican who drinks moderately will die sooner than another manof the same age ; indeed, even if we could infer this, we should still have to consider whether the unhygienic surroundings, poor accommodation and excessive hours of labour of many liquor establishments rather than the drinking of alcohol might not chiefly contribute to the result.

Sickness and mortality of abstainers and non-abstainers in certain Friendly Societies.

We next turn to the statistical experience of certain large Friendly Societies, reported upon nearly 30 years ago by Mr. F. G. P. Neison.* Comparing the Rechabites (a society of total abstainers) with the Oddfellows and Foresters, a difference very similar to that found in the experience of the United Kingdom Temperance and General Provident Institution is seen. The Rechabites had only 69 per cent. of the deaths calculated on the basis of the Foresters' experience, and their expectation of life at age 30 was more than 4 years longer than that of the Foresters. This comparison, however, probably overstates the advantage, as the Rechabites' statistics cover the period 1878-1888, while the Foresters' data were for 1871-5 and the Oddfellows' 1866-70. With regard to sickness, the average weeks of sickness claim per member were higher among the Rechabites up to age groups 40-50, but lower for ages 50-60 and 60-70 than in the non-abstaining societies. The average numbers of weeks of sickness, not per member, but per member *sick*, were about the same among Foresters and Rechabites, and the actuary concluded that the higher general rates at earlier ages among the Rechabites were due to less perfect medical examination at entrance, his

* F. G. P. Neison.—The Rates of Mortality and Sickness according to the experience for the ten years 1878-87 of the Independent Order of Rechabites (Salford Unity) Friendly Society. London, 1889.

reason being that new entrants showed a much higher percentage of sickness claims than members of the same age but longer standing in the society. This, which is contrary to the usual experience of Friendly Societies, pointed, in his opinion, to less careful selection of entrants.

As a whole these results concord with the life office experience detailed above. The obvious criticisms to which they are subject are (1) the Rechabites were a very much smaller society than either of the non-abstaining societies; both the Oddfellows and the Foresters' statistics covered in each case more than ten times as many years of life and more than 15 times as many deaths, as the Rechabites, while the comparison does not relate to the same calendar years. (2) Both occupational and geographical distribution may be important factors of mortality, especially in industrial populations, and neither could be analysed.

Conclusions.

The observations we have offered and the illustrations quoted indicate the necessity of being cautious in drawing deductions in respect of the relation obtaining between the consumption of alcoholic beverages and longevity. We think, however, that it is legitimate to conclude :—

(i) That the death-rate is lower and the expectation of life longer in the section of an Insurance Society admitting only total abstainers from alcohol than in the section admitting those who are not abstainers from alcohol.

(ii) That the statistics of mortality are more favourable for abstainers than are the returns for other Societies making no such distinctions, and which issue policies chiefly to persons of a more prosperous social class.*

* The validity of the argument has been impugned on technical grounds, the practical importance of which cannot be determined.

(iii) That the results at present published of Prof. Raymond Pearl's field investigation are consistent with those deduced from Life Assurance Statistics.

(iv) That Friendly Society data are concordant with those of the Life Insurance Offices in this respect.

(v) That the official statistics issued by the Registrar-General indicate an exceptionally heavy mortality among persons occupied in the liquor trade.

We repeat that it does not follow from these conclusions that a consistently moderate use of alcoholic beverages shortens life, since we cannot sort out from the data brought into comparison those instances in which the habitual abuse of alcohol produces disease or death, or in which accidental abuse has a like consequence, nor can we exclude many other social factors operating for or against longevity.

Our duty is merely to assess the value of the evidence dispassionately. Since it is admittedly proved that in comparisons extending over many years and embracing different social classes, non-abstainers, including an unknown proportion of excessive drinkers, do not live so long on the average as abstainers, anyone is entitled to conclude that total abstinence is a good practical rule of conduct for those who desire to live more than the average term of years. What we have not proved and, from the evidence before us, cannot prove, is that the moderate use of alcoholic beverages, employing the word moderate not in the specialised sense of Prof. Pearl's classification but as it is ordinarily used in everyday life, has any effect at all, one way or the other, upon longevity. It may be possible for Prof. Pearl, or for some other investigator having command of similar material, to answer this question in the near future. We cannot do so, and anyone who asserts that the evidence presented in this chapter does answer the question draws a conclusion which we believe to be unwarranted by the facts.

CHAPTER XI.

Conclusions.

We have now completed our survey of the present state of scientific knowledge regarding alcohol, considered in its several aspects as a food, a drug and a poison. It remains to sum up in this final chapter the main facts which we have ascertained, and to draw from them such inferences as have a practical bearing on the use of alcoholic beverages under the conditions of everyday life.

Main action of alcohol confined to nervous system.

The first conclusion to which this review of the evidence leads us is, that apart from the results of its continued excessive use, the main effects of alcohol that have any real significance are due to its action on the nervous system. As we have seen in the chapters dealing with these several points, the result of scientific research concerning the action of alcohol on the respiration, the circulation, the digestion, the muscular system, is to show that, so far as direct action is concerned, alcohol, when administered in moderate doses, in dilute form and at sufficient intervals, has no effect of any serious and practical account.

Action of alcohol narcotic and not stimulant.

A further conclusion of capital importance which emerges with equal clearness is that the action of alcohol on the nervous system is essentially sedative, and—with the possible exception of its direct influence on the respiratory centre—is not truly stimulant. The popular belief in the stimulating properties of alcohol, as regards nervous and other functions, seems to be of purely sub-

jective origin and illusory. The apparent stimulation is in the main, if not wholly, an effect of the narcotic influence of the drug, which, as we have seen, dulls the drinker's perception of unpleasant conditions in himself and his surroundings, and may make him feel better, more efficient and stronger than he really is.

Effects which are apparently of a different character—effects such as the increased loquacity and freer gesticulation produced by alcohol—which are usually interpreted by the drinker, if not by those about him, as evidences of stimulation, are really narcotic effects; they result from the removal of the control exercised by the higher nervous centres, a control which enables the individual to weigh his words and acts, and renders him self-critical and solicitous as to the impression he is making on other people. The removal of this control and the decrease of critical self-consciousness are, in fact, the most constant and characteristic effects of alcohol, whether in the moderate dose which diminishes restraint and imparts courage to the diffident speaker, or in the excessive dose which gives rise to the verbose diffuseness of drunkenness.

We may see a further illustration of the true nature of the drug action of alcohol in its seemingly contradictory effects on persons of different temperament, when competing in games of skill in which temperament is an important factor. The cool and self-controlled player will generally find that even a small or moderate amount of alcohol will impair the accuracy of his play, while, on the other hand, it may improve the performance of the excessively nervous player by decreasing his over-anxiety and self-consciousness.

Objective effects of drug on nervous system.

In reality, so far as the effects of the drug on the nervous system are objectively perceptible, they are always manifested in a lowering of functional activity. We have seen

that this effect is appreciable in the case of the simplest reflex actions, but that it acquires increasing prominence with increasing complexity of the response chosen for the test; so that a dose which produces no obvious change in the performance of a simple act involving no skill or exact adjustment of movement, will definitely impair the precision of an act demanding a greater delicacy of control and co-ordination.

When narcotic action may be useful.

The conclusion indicated by our review of the scientific evidence, that alcohol is essentially a narcotic, does not imply an adverse judgment as to its value in all circumstances. There is nothing intrinsically good about a stimulant, and nothing intrinsically bad about a narcotic. Each has its proper utility under given conditions. But these conditions are different for each, and on that account it is important that there should be no confusion as to whether a drug belongs to one category or the other. When stimulation of nervous function is really needed—when the individual has to meet an emergency which calls for the exercise of his highest powers of perception and judgment—alcohol is not merely useless, it is certainly and unequivocally detrimental. On the other hand, there are emergencies where, though the individual may also imagine that he needs to be braced up nervously, he would in fact be assisted far more by a relaxation than by an increase of tension, and here the sedative action of alcohol, so far as the immediate effect is concerned, may be advantageous. The value widely attributed, during the war, to the rum ration, under the conditions of acute discomfort, cold and nervous strain inseparable from trench warfare, may be explained in this way. It is in this way, too, that alcohol helps the timid speaker to overcome his diffidence, and to free himself from the inhibitions that prevent him from finding his words. Similarly, an exhausting and worrying

day may leave a condition of tension and irritability which interferes with appetite and digestion ; and in such a condition, and in some persons, it may be that wine or other dilute form of alcohol taken with the evening meal, will assist the assimilation of food. Again, persons who have overworked to such an extent that they have become too tired to rest, may be enabled to sleep when they have taken a small amount of alcohol—a fact which in itself illustrates the narcotic properties of the drug. It is to these properties, too, that alcohol mainly owes its reputation as a restorative in emergencies, as, for instance, in fainting from pain or fright : its value in such conditions is due, not to any direct stimulation of the nervous system or the heart by the drug, but to its weakening of the excessive check on the heart's action exercised by the nervous centres, and to its sedative influence on the higher levels of the brain, relieving pain and anxiety and increasing the general comfort of the patient.

Limitations to value of alcohol as a food.

Somewhat analogous considerations apply to the use of alcohol as a food. As we have seen, it undoubtedly has a food value, when regarded exclusively from the point of view of its capacity to act as a fuel in the body. Moreover, alcohol is absorbed very rapidly, and unlike ordinary food-stuffs, it does not require to undergo digestion before it can make its way into the blood. It may, therefore, be useful as a constituent of the diet in conditions of emergency, as in acute diseases, when the assimilation of ordinary foods is more or less interfered with. But these advantages are accompanied by drawbacks which, though they may be disregarded in the special and transitory circumstances of an acute illness, are amply sufficient to condemn the use of alcohol as an ordinary source from which to supply the energy required by the body in health.

In the first place, alcohol is unsuited for the latter purpose because of its immediate drug action, which, as pointed out above, involves, even with small doses, some impairment of the higher nervous functions, so that efficiency is lowered in all forms of work that demand the exercise of these functions. But quite apart from this immediately detrimental influence of alcohol on the higher activities of the brain, there is a second serious limitation of its utility as a food. To understand this limitation, we must again refer to what we have already indicated as an important point of difference between alcohol and other foods—namely, to the fact that, while these latter foods are stored in the body, in altered form, to be drawn upon as required by the muscles and other parts of our mechanism, alcohol cannot be so stored; it remains as alcohol in the blood and the organs generally, until it is destroyed by combustion. As that process is gradual, the drug, when in sufficient amount, can exercise a seriously injurious effect upon the tissues of the body. If it is taken frequently, so that a new dose enters the circulation before the previous one has been eliminated, the tissues are seldom free from this harmful influence, and the pathological changes and disorders follow which we have described under the heading of chronic alcoholism.

Thus, with regard to the use of alcohol as a food, we reach conclusions which, from a practical point of view, are substantially consonant with those to which we were led by our consideration of its utility as a narcotic drug. It unquestionably is a food, in the sense that it can be used to supply a considerable proportion of the fuel needs of the body, and it has even special properties, due to the readiness with which it can be absorbed into the system, that may give it an added value in some conditions of disease and convalescence; but it is a food suitable only for such emergencies. To use it, as it is very commonly used by people who do not appreciate its limitations and

drawbacks, as a staple food for muscular work, is to run a grave risk of damage to health and efficiency—how grave we have seen when discussing the alcoholic mortality of industrial drinkers.

Nutritional value of beer, as compared with other alcoholic liquors.

In the ordinary alcoholic beverages there are other constituents besides ethyl alcohol; does their presence qualify this conclusion regarding the disadvantages of alcohol as a food for work? In this country, the question arises mainly in relation to beer, which contains, in addition to alcohol, an appreciable amount of other substances possessing nutritive value, notably dextrin and other carbohydrate bodies. It is generally estimated that a pint of beer, of original gravity 1055, owes rather more than half its food value to its contained alcohol; so that, regarded as foods, malted liquors, at all events when brewed at the gravity we have named, are open, though in a smaller measure, to the objections which we have seen to apply to the stronger alcoholic beverages; they cannot be used as a large element in the working diet without danger of inducing such bodily disorders as may be incurred through the constant exposure of the tissues to the action of alcohol. It is obvious that, as alcoholic strength diminishes, the danger indicated becomes less.

Use of alcohol as an aid to work physiologically unsound.

So far we have considered alcohol mainly in relation to its influence on the working efficiency of the drinker, this being, in fact, the relation we ordinarily have in mind when we speak of the food value of alcohol, or of what are erroneously regarded as its "stimulant" properties. And we have found ample reason to conclude that the taking of alcoholic beverages to promote such efficiency is not only useless or even detrimental in immediate effect, but is also

likely to be, in its ultimate results, seriously injurious to health. In the light of our knowledge of how alcohol acts in the body, there can be no question that its habitual use by the worker as a substitute for food, or in the belief that it gives a fillip to energy, is physiologically unsound.

Conditions under which use of alcoholic beverages may be physiologically permissible.

The matters summarised in the preceding paragraphs have necessarily bulked largely in this report, and bulk even more largely in popular discussions concerning alcohol. It must, however, be said that among the causes that have contributed to the world-wide habit of taking alcohol, its action as a food, as an aid to digestion, or as a supposed cardiac and respiratory stimulant, are of secondary importance. In truth, men in general do not drink alcoholic beverages because they regard them as "foods," nor do those who abstain from these drinks do so merely because they doubt their food value. The use of alcohol is dictated by the fact that, to the majority, the taste of alcoholic beverages and the immediate effects of alcohol are agreeable, and that the pleasure derived therefrom outweighs their estimate of remoter harm, if, indeed, they give ulterior considerations any thought at all. To the abstainer either the taste or the immediate effects are not agreeable, or the remoter ill, whether real or imaginary, seems more important. Each class manufactures arguments in favour of its own line of conduct.

So far as these arguments have to do with the social evils which result from the excessive use of alcoholic liquors, they lie outside the scope of the present discussion: the moral problems which they raise cannot be solved by directly scientific methods. We deal here solely with the physiological aspect of the alcohol question, and our consideration of this aspect leads us to recognise that the agreeable effects which the majority of people experience from the use of alcoholic

beverages can be produced by doses of alcohol—moderate in quantity and taken in adequate dilution and at sufficient intervals—which will not, in normally constituted persons, be attended with appreciable risk to physical or mental health. It is foreign to the aim of the present statement to inquire whether the pleasure associated with the moderate use of alcohol by the many is inseparably connected with, or leads inevitably to, the evils arising from its abuse by the few, nor is it relevant for us to examine the effect of the alcoholic habit on social efficiency or national expenditure.

The present statement is not concerned with the social evils arising from the excessive consumption of alcohol as a beverage ; nor is it concerned with ethics, administration, or national economy. We are dealing solely with the physiological facts so far as it is possible to ascertain them in the present position of knowledge, and within the prescribed limitation we can only say that the moderate use of alcoholic beverages is physiologically permissible only so long as it conforms to the special conditions which we have seen to be necessary in order to avoid the poison action of the drug. The risks of this poison action that have to be guarded against and the precautions to meet these risks may be summed up for practical purposes in the following propositions :—

(i) To avoid a continued action on the tissues, such an interval should elapse between the times when alcoholic beverages are drunk as will prevent the persistent presence of a deleterious amount of the drug in the body.

(ii) To avoid direct injury to the mucous membrane of the stomach and to decrease the risk of inebriation, alcohol should not be taken in concentrated form and without food.

The temperate consumption of alcoholic liquors in accordance with these rules of practice may be considered to be physiologically harmless in the case of the large majority of normal adults ; this conclusion, it may be added, is fully borne out by the massive experience of mankind in wine-drinking and beer-drinking countries.

On the other hand, it is certainly true that alcoholic beverages are in no way necessary for healthy life ; that they are harmful or dangerous if the above-mentioned precautions are not observed ; further, that they are definitely injurious for children and for most persons of unstable nervous system, notably for those who have had severe injuries of the head or who have suffered from attacks of mental disorder, or from nervous shock.

APPENDIX I.

TOTAL CONSUMPTION, AND CONSUMPTION PER HEAD OF ESTIMATED POPULATION, OF BEER, SPIRITS, AND WINE IN THE UNITED KINGDOM IN EACH FINANCIAL YEAR FROM 1897 TO 1923.

Year ending 31st Mar.	TOTAL.			PER HEAD OF POPULATION.		
	BEER. Standard Barrels.*	SPIRITS. Proof Gallons.†	WINE. Gallons.‡	BEER. Galls.*	SPIRITS. Proof Galls.†	WINE. Galls.‡
1897	33,581,000	47,927,000	15,810,000	30·23	1·20	·40
1898	35,083,000	48,279,000	16,004,000	31·28	1·20	·40
1899	35,853,000	48,550,000	16,862,000	31·66	1·19	·41
1900	36,625,000	50,126,000	17,147,000	32·04	1·22	·42
1901	36,045,000	45,403,000	15,088,000	31·24	1·09	·36
1902	35,442,000	42,088,000	14,865,000	30·46	1·00	·35
1903	35,425,000	43,354,000	15,399,000	30·18	1·03	·36
1904	34,791,000	42,205,000	13,442,000	29·39	·99	·32
1905	33,862,000	40,109,000	11,913,000	28·36	·93	·28
1906	33,559,000	39,259,000	11,784,000	27·70	·90	·27
1907	33,789,000	39,847,000	12,347,000	27·81	·91	·28
1908	33,904,000	39,697,000	12,124,000	27·66	·90	·27
1909	32,806,000	38,940,000	11,393,000	26·53	·87	·26
1910	32,390,000	26,008,000	11,446,000	25·96	·58	·25
1911	33,085,000	30,888,000	12,529,000	26·27	·68	·28
1912	34,362,000	30,887,000	11,104,000	27·18	·68	·24
1913	34,099,000	30,736,000	11,167,000	26·86	·67	·24
1914	35,446,000	32,596,000	11,637,000	27·69	·71	·25
1915	32,575,000	34,345,000	10,078,000	25·60	·75	·22
1916	29,646,000	35,597,000	11,138,000	23·66	·77	·25
1917	25,923,000	23,996,000	8,929,000	21·49	·52	·20
1918	12,471,000	14,681,000	7,613,000	(*a*)	(*a*)	(*a*)
1919	12,721,000	15,591,000	13,181,000	(*a*)	(*a*)	(*a*)
1920	24,757,000	24,267,000	19,934,000	19·31	·53	·43
1921	26,284,000	20,162,000	12,330,000	20·15	·43	·26
1922	23,201,000	17,661,000	11,173,000	17·67	·37	·24
1923 (*b*)	19,809,000	15,158,000	12,316,000	16·08	·34	·28

* A "standard barrel" represents 36 gallons of beer of an "original gravity" of 1055 (water taken as 1000) and is the unit on which taxation is based. By "original gravity" is meant the specific gravity of the worts, before fermentation, from which beer is brewed. As beer is brewed on the average lighter than the standard, the number of actual "bulk" or "liquid barrels" annually

consumed is higher than the corresponding number of standard barrels given in the Excise returns. In column 5, a "gallon" of beer means $\frac{1}{36}$ of a standard barrel.

† A "Proof gallon" is a gallon of "Proof Spirit," in terms of which the strength of distilled spirits is usually expressed in this country. Proof Spirit is a mixture of alcohol and water having, at a temperature of 60° F. a specific gravity of ·91976, compared with water taken as unity. The mixture contains 49·28 % of alcohol by weight and 57·10 % by volume.

‡ The figures referring to the consumption of wine indicate gallons irrespective of alcoholic strength, which, of course, varies very widely in the case of different wines.

(*a*) The per head quantities for the years ended 31st March, 1918 and 1919 cannot be stated, no complete estimate of the population in those years being available.

(*b*) The figures shown for the year 1923 are those for Great Britain and Northern Ireland only.

APPENDIX 2.—Annual Death Rates (England and Wales), from (*a*) Alcoholism, and (*b*) Cirrhosis of the Liver at all Ages to a Million Living from 1891 to 1922.

Years	Alcoholism.			Cirrhosis of the Liver.		
	Males and Females.	Males.	Females.	Males and Females.	Males.	Females.
1891	71	94	49	125	148	104
1892	67	86	49	122	142	104
1893	73	93	55	120	139	103
1894	61	76	47	115	136	96
1895	67	84	51	118	133	104
1896	71	91	52	122	140	106
1897	77	97	58	133	151	115
1898	78	98	59	132	152	112
1899	90	113	69	142	167	119
1900	113	132	95	144	162	127
1901	96	113	80	132	151	115
1902	84	105	65	123	144	104
1903	77	92	63	118	136	100
1904	70	86	55	118	135	101
1905	65	79	52	118	132	105
1906	66	81	53	112	127	98
1907	63	79	49	112	123	102
1908	55	65	45	104	121	89
1909	47	68	37	100	120	81
1910	42	50	34	90	106	75
1911	45	57	34	91	105	78
1912	45	55	36	93	108	79
1913	52	62	42	97	115	80
1914	53	64	43	99	117	82
1915*a*	43	53	35	93	120	70
1916*a*	29	40	21	79	111	54
1917*a*	19	26	14	63	97	38
1918*a*	10	17	5	46	73	28
1919	10	17	5	37	53	25
1920	15	24	7	42	60	27
1921*b*	15	22	9	47	66	30
1922*b*	14	21	8	46	64	30

The material for this Table has been obtained from the Annual Reports of the Registrar General, and from information supplied by Dr. T. H. C. Stevenson, Superintendent of Statistics at Somerset House.

(*a*) Based upon Civil deaths and Civil population.
(*b*) Including deaths classed to the International heading No. 113C prior to 1921.

APPENDIX 3.

COMPARATIVE MORTALITY OF MALES AGED 25-65 YEARS IN THE CHIEF OCCUPATIONAL GROUPS (ENGLAND AND WALES) (*a*) FROM ALCOHOLISM, (*b*) FROM ALCOHOLISM AND LIVER DISEASES TAKEN TOGETHER, AND (*c*) FROM ALL CAUSES, IN THE PERIOD 1910-1912.

NOTE.—The "comparative mortality" figure from any given disease in any given occupation indicates the number of deaths from that disease which would occur in a population corresponding in numbers and in age constitution with the standard population, but composed solely of persons engaged in the particular occupation in question. In this table the "standard population" is the population of males, aged from 25 to 65 years, which **in the period 1900–1902** furnished 1,000 deaths from all causes.

GROUP.	(1910–1912.)		
	Alcoholism.	Alcoholism & Liver Diseases.	All causes.
All Males	7	23	790
Clergyman, Priest & Minister*	2	11	443
Railway Engine Driver, Guard, Porter, etc.	2	11	586
Platelayer, Railway Labourer	2	11	623
Agriculturists	3	11	474
Coal Miner	3	13	727
Shipbuilding	5	12	633
Printers	5	14	773
Building Trade	5	17	726
Metal Workers	5	19	804
Shoemaker	6	17	820
Textile Manufacturer ..	6	19	799
Commercial Clerk, Insurance Agent.	6	22	802
Tailor	6	22	799
Baker	7	19	664
Carmen, Carriers	7	21	900
Shopkeepers	8	27	683
Commercial Traveller ..	9	32	724
Medical Profession*	9	38	693
Coach, Cab, Bus	12	29	921
Messenger, Porter	13	33	1,137
Barrister, Solicitor*	13	39	627
Seaman and Merchant Service	18	34	1,485
Butcher	18	56	885
General Labourer	20	50	2,301
Dock Labourer	26	43	1,127
Costers, Hawkers	30	52	1,507
Publican, Innkeeper, etc. ..	50	152	1,265

For the above Table the Advisory Committee are indebted to Dr. T. H. C. Stevenson, Superintendent of Statistics at Somerset House.

* Based on relatively small numbers.

APPENDIX 4.—Percentage of Proof Spirit and of Absolute Alcohol in Various Beverages.

	Original Gravity.*	Percentage of Proof Spirit.	Percentage of Absolute Alcohol† (by weight)	Percentage of Absolute Alcohol† (by volume)
Spirits—				
At 25° u.p. ..	—	75·0	35·9	42·8
At 30° u.p. ..	—	70·0	33·3	40·0
At 35° u.p. ..	—	65·0	30·8	37·1
At 40° u.p. ..	—	60·0	28·3	34·3
At 50° u.p. ..	—	50·0	23·4	28·6
Wines—				
Port	—	35·3	16·4	20·2
Sherry	—	33·0	15·3	18·9
Madeira.. ..	—	34·0	15·8	19·5
Tarragona ..	—	30·0	13·9	17·2
Australian Burgundy.	—	24·8	11·5	14·2
Italian Red Wine	—	23·9	11·1	13·7
French Burgundy (Red)	—	25·0	11·6	14·3
Italian WhiteWine	—	20·6	9·5	11·8
French Burgundy (white)	—	25·0	11·6	14·3
Bordeaux (white)	—	20·0	9·2	11·5
,, (red)..	—	20·0	9·2	11·5
Cider (bottled)..	—	7·4	3·4	4·2
Beers (English)—				
" Burton " heavy	1072°	13·0	6·0	7·5
,, light	1056°	9·7	4·5	5·6
Stout heavy ..	1056°	9·3	4·2	5·3
,, light ..	1049°	8·2	3·7	4·7
Bitter Ale (1) ..	1053°	9·3	4·3	5·4
,, ,, (2) ..	1041°	7·7	3·5	4·4
Mild Ale (1) ..	1041°	7·2	3·3	4·1
,, ,, (2) ..	1034°	5·9	2·7	3·4
,, ,, (3) ..	1030°	5·6	2·6	3·2
Porter	1034°	6·5	3·0	3·7
Beers (Import)—				
Dutch	1048·3	8·1	3·7	4·7
German ..	1050·5	8·5	3·9	4·9
Danish	1052·5	9·1	4·2	5·2

The alcoholic strengths of the wines, beers and cider, recorded in this Table have been supplied by the Government Chemist from the results of examination of samples examined at the Government Laboratory.

The English beers represent samples obtained from public houses in London.

* See footnote to Appendix 1.

† From Thorpe's Alcoholometric Tables ; London, 1915.

APPENDIX 5.

Amount of Proof Spirit and of Absolute Alcohol (by volume in usual Retail Measures of the ordinary Alcoholic Beverages.

Note on Retail Measures.—Beer, wine or spirits sold by the "glass" may be supplied in any unstamped vessel, and there is no legal obligation as to the quantity of fluid which a glass of any of these beverages should contain. In practice a glass of beer usually contains $\frac{1}{5}$ of a quart, *i.e.*, a little less than $\frac{1}{2}$ pint, and it may contain only $\frac{1}{6}$ quart. In the case of spirits, a "glass" of whisky, more often described in the South as a "large whisky," contains generally from $\frac{2}{5}$ to $\frac{1}{2}$ gill; a small glass contains $\frac{1}{5}$ gill, or sometimes as little as $\frac{1}{6}$ gill.

The "glass" of wine is also a very variable quantity, ranging from $\frac{2}{5}$ of a gill to about $\frac{3}{4}$ gill; the latter being the average capacity of the dock glass in which port is ordinarily sold at the bar.

	Proof Spirit.	Absolute Alcohol.	
	Fluid ounces.	Fluid ounces.	Cubic Centimetres.
BEERS.			
Light Pale Ale (original gravity 1042·6)			
1 pint ..	1·58	·90	25·6
½ pint ..	·79	·45	12·8
glass (⅖ pint) ..	·63	·36	10·2
Mild Ale (original gravity 1037·8)			
1 pint ..	1·16	·66	18·6
½ pint ..	·58	·33	9·3
glass (⅖ pint) ..	·46	·26	7·4
WINES.			
Claret, ½ pint	1·70	·97	27·6
Sherry, glass (½ gill) ..	·74	·42	11·9
Port, dock glass (¾ gill) ..	1·32	·75	21·3
SPIRITS—			
at 30° u.p.			
Large glass (½ gill)	1·75	1·00	28·4
Small glass (⅕ gill)	·70	·40	11·3
at 50° u.p.			
Large glass (½ gill)	1·25	·71	20·1
Small glass (⅕ gill)	·50	·28	8·0

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